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Report 4472

Development of a Computer Simulation Model for the Seaborne Mobile Logistic System (SMLS) at the Amphibious Task Group/Marine Amphibious Brigade (ATG/MAB) Level

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20034

Development of a Computer Simulation Model for the Seaborne Mobile Logistic System (SMLS) at the Amphibious Task Group/Marine Amphibious Brigade (ATG/MAB) Level

Paul Hubai

Joseph J. Fuller

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Computation and Mathematics Department

September 1974

Report 4472

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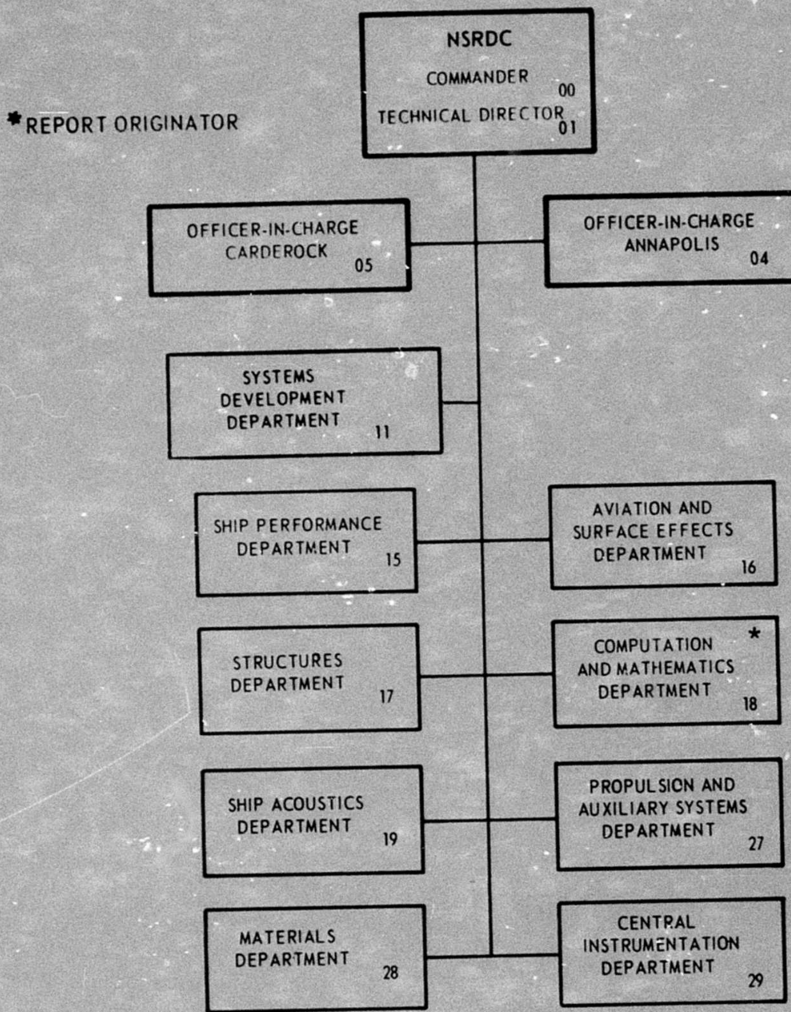

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A computer simulation model has been developed for the Seaborne Mobile Logistic System (SMLS) at the Amphibious Task Group/Marine Amphibious Brigade (ATG/MAB) level to permit evaluation of the concept. This interactive simulation model permits simultaneous evaluation of all major subsystems of SMLS. System procedures, facilities, equipment, and design may be varied to evaluate the effects of such changes on the total system. The model is written in the simulation language TRANSIM. This report

contains a description of the modeling process, the model logic flow, and the input/output parameters.

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1. INTRODUCTION

The Seaborne Mobile Logistic System (SMLS) is an evolving concept for providing combat service support to a Marine Landing Force from the ships of an Amphibious Task Force. The SMLS concept retains the logistic support system aboard the ships and provides the necessary logistic support from the ships directly to the Landing Force elements ashore. To reduce the establishment of facilities ashore, SMLS makes maximum use of ship-based facilities but retains the capability to transfer the entire support system ashore should circumstances dictate.

SMLS is designed to be used primarily by small amphibious forces, especially an Amphibious Task Unit/Marine Amphibious Unit (ATU/MAU) and an Amphibious Task Group/Marine Amphibious Brigade (ATG/MAB). SMLS will be used in crisis-control situations and in sub-theater low- and mid-intensity conflicts which are not accompanied by a significant naval threat. The SMLS Second Interim Report[1] gives a complete description of the SMLS concept.

Once operational concepts, procedures, and techniques within SMLS have been established, test and evaluation of the system may be accomplished through operational exercises or through simulated war games on the Navy Electronic Warfare Simulator (NEWS) at the Naval War College. However, these empirical methods require significant time to complete each test case, are restricted by availability of facilities, present the output in a form that requires additional analysis, and are costly in man-hours and dollars. In addition, orderly control over SMLS procedure is

1. CNO (OP-323)/CMC (AO4R-bls-2) Joint Letter of 11 Oct 1973, Subj: Second Interim Report, Seaborne Mobile Logistic System (SMLS); with Enclosure (1), Part I of the Second Interim Report of Refined ATU/MAU and Interim ATG/MAB Seaborne Mobile Logistic System (SMLS).

difficult to maintain and the sequence of actions is difficult to evaluate quantitatively.

Therefore, an analytical method was needed which would alleviate these problems and permit more economical and efficient analysis of SMLS. A simulation model represents an excellent vehicle for generating analytical representations of amphibious exercises and testing the SMLS concept. In the original SMLS study plan[2], one element of the Naval Ship Research and Development Center (NSRDC) support to the Marine Corps Development and Education Command (MCDEC) consisted of developing a computer simulation model for SMLS. The simulation model was to be interactive to permit the simultaneous evaluation of all major subsystems (e.g., supply, medical, maintenance) of SMLS operating together as a totally integrated system, taking into account the complex subsystem interactions and interrelations. The model was constructed according to this requirement and has been used to optimize SMLS procedures.

The SMLS computer simulation model provides the following capabilities:

- A means to test policies and procedures as a supplement to fleet exercises.
- A means to study the interaction of subsystems within the SMLS concept.
- A means to modify and revise specified subsystems as desired by experts in that particular area, and to evaluate these changes on the overall system.

2. CNO/CMC ltr NAMAF/jin, ser 213P37 of 17 Nov 1970, Subj: Study Plan for the Seaborne Mobile Logistic System (SMLS) Task of the NAMAF Study; forwarding of; with enclosure (1), Study Plan for the SMLS task of NAMAF.

° A means to evaluate various SMLS configurations at low and medium levels of conflict.

Figure 1 illustrates the evaluation process using the SMLS simulation model. Various mission scenarios, logistic requirements, and SMLS resources are specified as input. Data which are dependent on mission scenario include troop lists, equipment lists, combat tempo, mission duration, ship-to-shore distance, and ship-to-battalion distance. The analyst uses the simulation model to test the system and to indicate, through the measures of effectiveness of each subsystem, problem areas which need detailed study. The appropriate subsystem coordinators then study the problem areas and suggest modifications, revisions in procedures and organizations, or reallocation of resources to obtain an improvement. These changes can then be incorporated into the simulation model and their effect on the overall system determined.

The ATG/MAB level model is the second in a series of simulation models developed for the SMLS concept. The first model developed was for the Amphibious Task Unit/Marine Amphibious Unit (ATU/MAU) level of operation.[3] The results of analysis using this model are presented in the SMLS Final Draft Report.[4]

3. Hubai, P., "Development of a Computer Simulation Model for the Seaborne Mobile Logistic System (SMLS) at the Amphibious Task Unit/Marine Amphibious Unit (ATU/MAU) Level," NSRDC Report 4114, Dec 1974.

4. Technical Director, SMLS Study, ltr D 050-41 FDMJr:jmn of 18 July 1974, Subj: Seaborne Mobile Logistic System (SMLS) Study; with Enclosure (2), Volume II Amphibious Task Unit/Marine Amphibious Unit (ATU/MAU) Analysis.

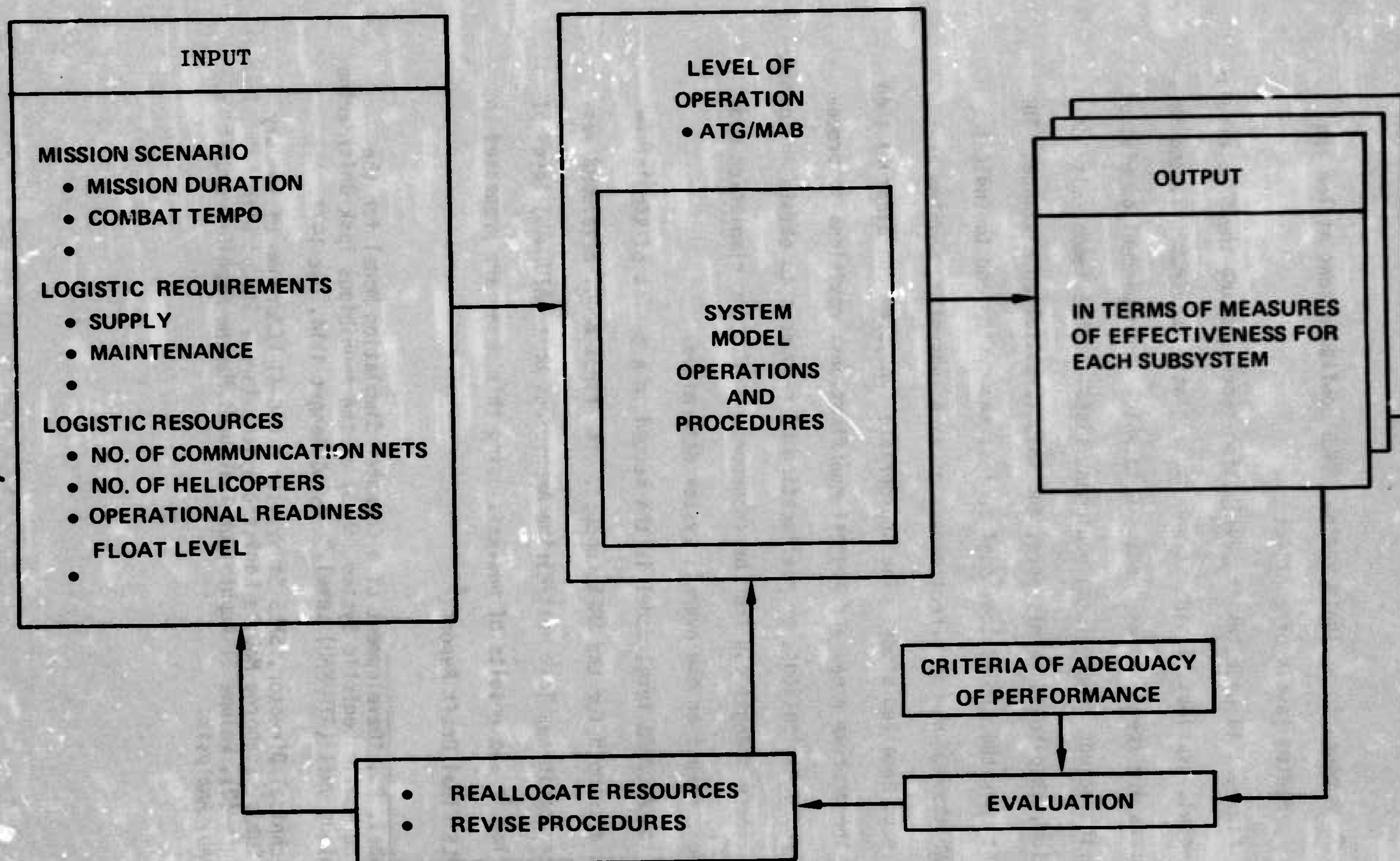


Figure 1. SMLS Evaluation Process Using Computer Simulation

The present report describes the logic of the ATG/MAB level simulation model. Its purpose is to provide an introduction to the ATG/MAB analysis report,[5] to provide an understanding of the ATG/MAB level model, and to provide an understanding of the SMLS concept as modeled at the ATG/MAB level of operation. This report was not designed to include a user's instruction section due to the limited nature of the model's application, the difficulties encountered with the TRANSIM methodology by analysts not familiar with TRANSIM, and the current plans to discontinue use of the model when the analysis is completed unless otherwise instructed by the CNO/CMC sponsors.

5. Hubai, P., and Fuller, J. "Analysis of Computer Simulation Results for the Seaborne Mobile Logistic System (SMLS) Concept Operating at the Amphibious Task Group/Marine Amphibious Brigade (ATG/MAB) Force Level," NSRDC Report 4473 (in review).

2. MODEL DEVELOPMENT

The SMLS simulation model was developed using TRANSIM[6], the general-purpose simulator developed by the University of California at Los Angeles. TRANSIM is a Monte Carlo-type simulator (i.e., it accounts for random variability of a system's performance by sampling data from pre-assigned probability distributions) which allows realistic modeling of real-life problem situations. The TRANSIM simulation methodology permits analysis of individual components (e.g., supply or maintenance subsystems) of a system as part of a total or integrated system (SMLS), taking into account complex system interrelationships and interactions. System procedures, facilities, equipment, and designs may be varied to evaluate the effects of such changes on the total system.

The TRANSIM approach defines the system to be modeled in terms of traffic units flowing through operating elements. The standard computer program of TRANSIM is not modified from one problem to another; rather, the system is modeled in basic building blocks of operating elements and traffic units. An operating element may be a ship, a coordination center, a communications network, or any other component of the system through which traffic units flow. A traffic unit may be a ship, a logistic request, equipment, or any other item which passes between operating elements. TRANSIM also defines the rules which govern the flow, the changes or traffic-unit conversions which the traffic units undergo, and the service times which the traffic units experience. A service time is the period of time required for an operating element to perform its service or function for a traffic unit.

6. "TRANSIM IV - User's Manual," University of California at Los Angeles, Report 7168, Dec 1971 (U).

In order to model the system using the TRANSIM approach, the boundaries of the system must first be determined. The boundaries set the limits of the problem to be analyzed. The boundaries of the Amphibious Objective Area (AOA) were chosen as the boundaries in the SMLS simulation model, but these boundaries could have been extended to include outside bases or CONUS. Within the system boundaries, the proper level of detail for describing the system must be chosen. This decision has far-reaching consequences in the requirement for input data, the usefulness of the simulation output, the amount of computer capacity required, and the cost of the simulation analysis.

The logic flow developed for the system, within the boundaries and at the chosen level of detail, is then defined in standard TRANSIM data forms. These standard data forms include the following information: the system physical plant (i.e., the operating elements which compose the system), system traffic (i.e., traffic units and traffic-unit conversions), system operating rules, and service times to perform the functions. The system operating rules include the operating schedule (i.e., specify when the facility is "open for business"), work schedules (i.e., specify when manpower is available), and the routing rules which direct traffic units between operating elements.

When the input data are complete, they are combined with the standard TRANSIM program for the simulation of the system. The TRANSIM simulator cycles through a single program routine which, at different times during the simulation, represents the operation of each of the system's operating elements. Data on the characteristics of operating elements are stored in the computer core memory during the simulation

run, and information on traffic units is held outside the core memory until it is scheduled to arrive in the system. Therefore, the amount of core required reaches a maximum when the flow of traffic units reaches a peak and does not depend on the total amount of traffic processed over the entire period.

The calendar of events is the basic control of the simulator. An event is defined as any change of state of the system, for example, a traffic unit completes a service time at an operating element. The calendar of events, a chronological listing of scheduled events, designates when and where each event will occur and identifies the traffic unit involved in the event. It uses an event-oriented clock which is incremented to the time of the next chronological event in a single step.

The TRANSIM standard program provides the output data requested by the analyst in the input data forms. The output can include a complete chronological record of all events occurring during the simulation or it may be in the form of summary statistics on the number of traffic units at an operating element during the simulation period, or on the time during which traffic units remain at an operating element. Summary reports also provide maximum, minimum, and average values of requested parameters during the report period, as well as the frequency distribution over the report period.

3. MODEL DESCRIPTION AND LOGIC FLOW

The SMLS ATG/MAB Simulation Model is concerned with the following five areas of operation which compose the SMLS:

- ° Communications
- ° Medical/Dental
- ° Supply
- ° Maintenance
- ° Transportation

Embarkation is also implicitly considered in the model as a fixed input, but not as a dynamic interaction. For example, the locations of helicopters, supplies, and equipment on the various ships are required inputs.

In constructing the model, logic for each subsystem was defined individually and then combined to provide a total system model with interactive subsystems. The following paragraphs describe how each subsystem has been modeled in the simulation model.

3.1 COMMUNICATIONS SUBSYSTEM

Three communications networks are used in the SMLS ATG/MAB simulation model. Two of these are SMLS logistic nets: (1) the Landing Force Logistic Net (LFLOG), which provides communications between the battalions, the Beach Support Area (BSA), and the Forward Logistic Coordination Center (FLCC), and (2) the Seabase Logistic Net (SBLOG), which provides communications between the FLCC, the Logistic Support Center (LSC), and the Snip Logistic Coordination Centers (SLCC's). Only logistic messages are transmitted over these nets. Two channels are available for each net; a voice channel used to transmit urgent messages and a teletype channel for

routine messages. The third net is the Helicopter Request Net (HRNET), which provides communications between the battalions, the FLCC, the BSA, and the Helicopter Control Section (HCS), and uses only a voice channel. The communications networks are diagrammed in Figure 2.

The operation of the LFLOG and SBLOG nets is described in Figure 3. Each message is first assigned a pre-transmission processing time at the communications center of the originator of the message. To simulate the rapid handling that urgent messages receive, a minimal processing time is assigned to urgent messages. Urgent messages are held in the voice channel queue until the net is free and routine messages are held in the teletype channel queue. When the voice channel is free the first message in the voice channel queue is selected for transmission. The selected message is assigned a service time* for transmission. The urgent message is then forwarded to the receiver.

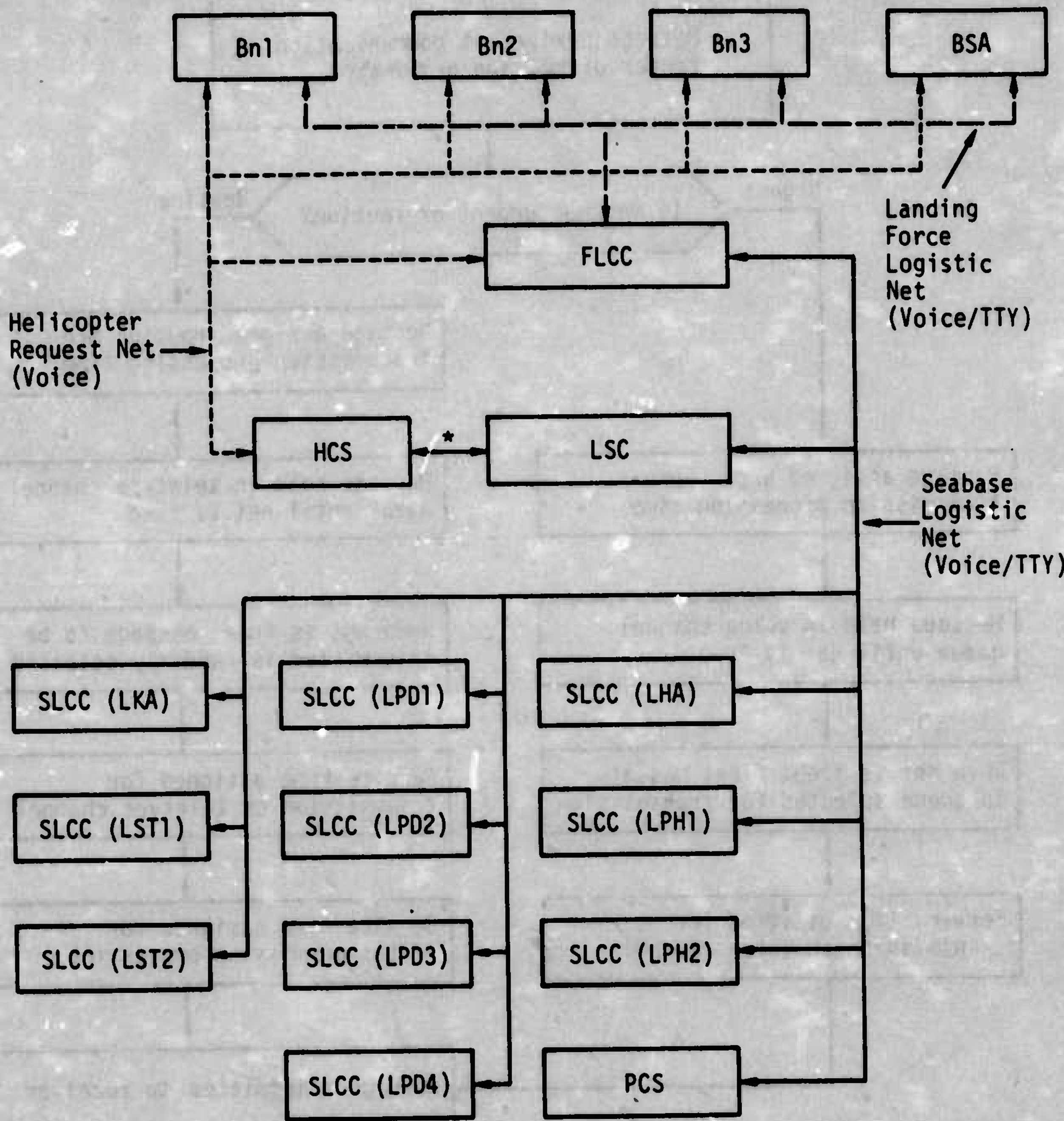
When the teletype channel is free, that routine message of each originating unit which has been in the queue the longest is put into competition for the net. The model randomly selects one of these messages for transmission. The selected message is assigned a service time for post-transmission and the message is transmitted. It is now assigned a post-transmission processing time.

The operation of the HRNET is the same as that of the voice channel of the LFLOG and SBLOG nets.

3.2 MEDICAL SUBSYSTEM

Requests for Medical Evacuation (MEDEVAC), including those resulting from dental causes, are introduced probabilistically into the model at the battalion level and distributed over the day by a bi-modal normal

*Service time assignment may be deterministic or stochastic.



* The LSC and HCS may be collocated, connected by hand wire, or if on different ships, assigned a special net.

Figure 2. SMLS ATG/MAB Simulation Model Communication Networks

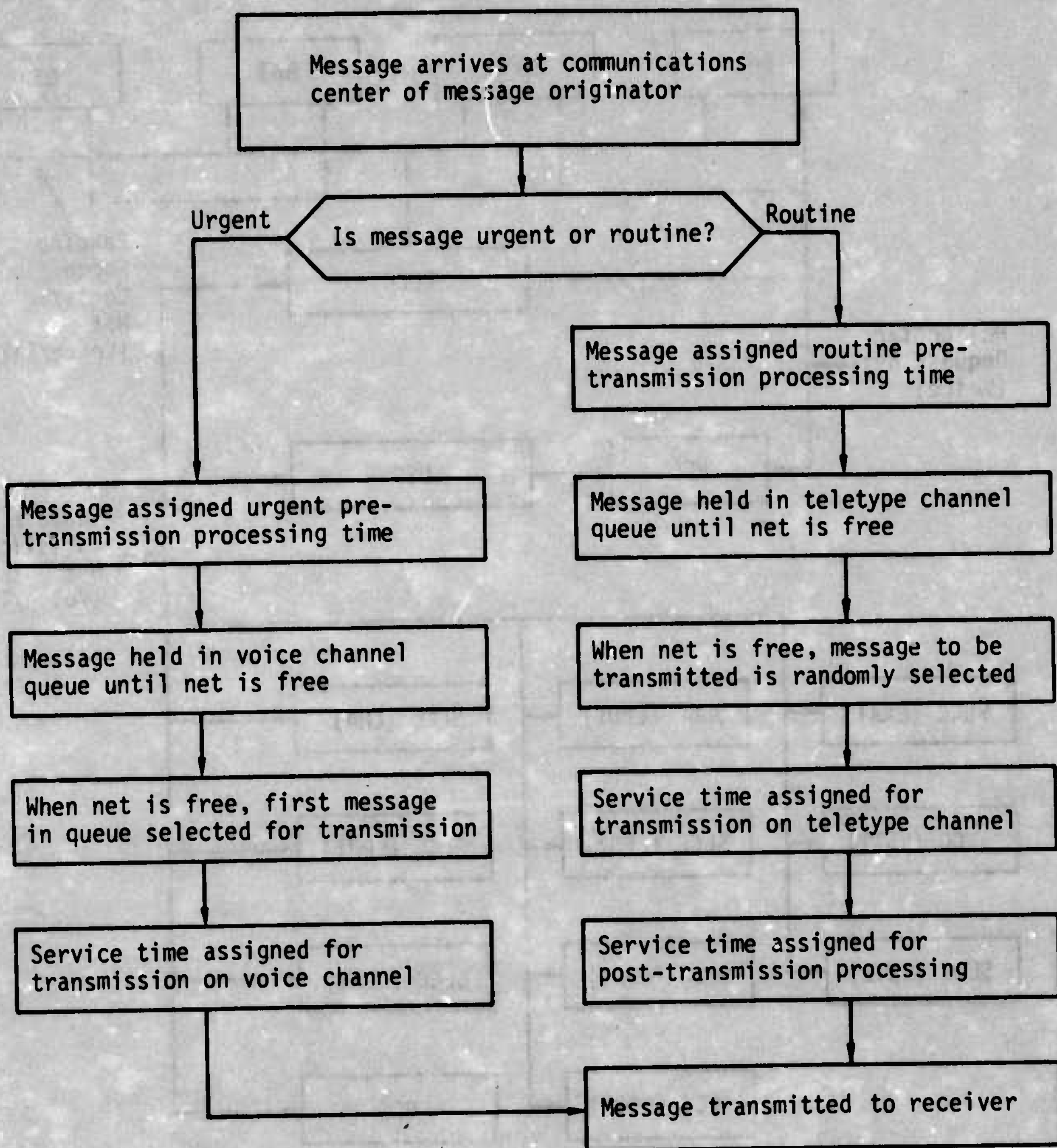


Figure 3. Operation of LFLOG Net and SBLOG Net

distribution to reflect two peak periods of conflict each day. Fifty percent of the requests are assigned an urgent priority and the remainder are routine. A service time representing battalion processing time is assigned to the MEDEVAC request, and the request is then forwarded to the unit's communications center. The request is assigned a pre-transmission processing time and after this time has elapsed, the request is held in a queue until it can be transmitted on the HRNET. When the request can be transmitted, it is assigned a service time for transmission on the HRNET. The request is then forwarded to the FLCC where it is held in a queue until it can be processed.

At the FLCC the MEDEVAC request is assigned a service time for FLCC processing. During FLCC processing, the means of transporting the casualties to the seabase is determined. The assignment of transportation depends on the priority of the request. If the priority of the MEDEVAC request is routine, the model first determines whether the time is during daylight hours; (i.e., 0600 to 1800 hours). If the time is not during daylight, a routine request is held until 0600 hours. During daylight hours the FLCC can assign the routine MEDEVAC request either to a dedicated MEDEVAC helicopter stationed at the FLCC or to a MARLOG flight. The criteria for this decision varied during the analysis of the ATG/MAB[5]. During daylight hours dedicated MEDEVAC helicopters are always assigned for transporting urgent casualties. Helicopters are also kept on alert status at the seabase to be used as backup MEDEVAC helicopters when all dedicated helicopters are in use or for night-time evacuation of urgent casualties.

If the decision is to assign a routine MEDEVAC request to a dedicated helicopter during daylight hours, or if the priority of the request is urgent, the FLCC determines whether a dedicated helicopter is available (i.e., not being used). If one is available, the MEDEVAC request is assigned to that helicopter. If a dedicated helicopter is not available, the FLCC decides whether a backup helicopter on standby at the seabase should be assigned the mission. If a backup helicopter is available, it is assigned to the mission. If one is not available, the request is held in a queue until a dedicated helicopter or a backup helicopter becomes available.

When a helicopter is assigned a MEDEVAC request, it takes off and proceeds to the casualty site. A service time is assigned for transit to the casualty site. When the helicopter arrives at the casualty site, it is assigned a service time to load the casualties. It then proceeds to the seabase with the appropriate service time assigned for transit. The destination of the casualties is determined from a probability distribution determined from the characteristics of the casualty receiving ships[5]. The helicopter lands at the designated ship as soon as deck space is available and a service time is assigned for unloading the casualties. The casualties are then forwarded to the treatment area. The treatment of casualties is not simulated in the model.

Figure 4 shows the Medical subsystem flow diagram.

3.3 SUPPLY SUBSYSTEM

Supply requests are generated by priority at the battalion level for delivery directly to the requesting company. Each request contains

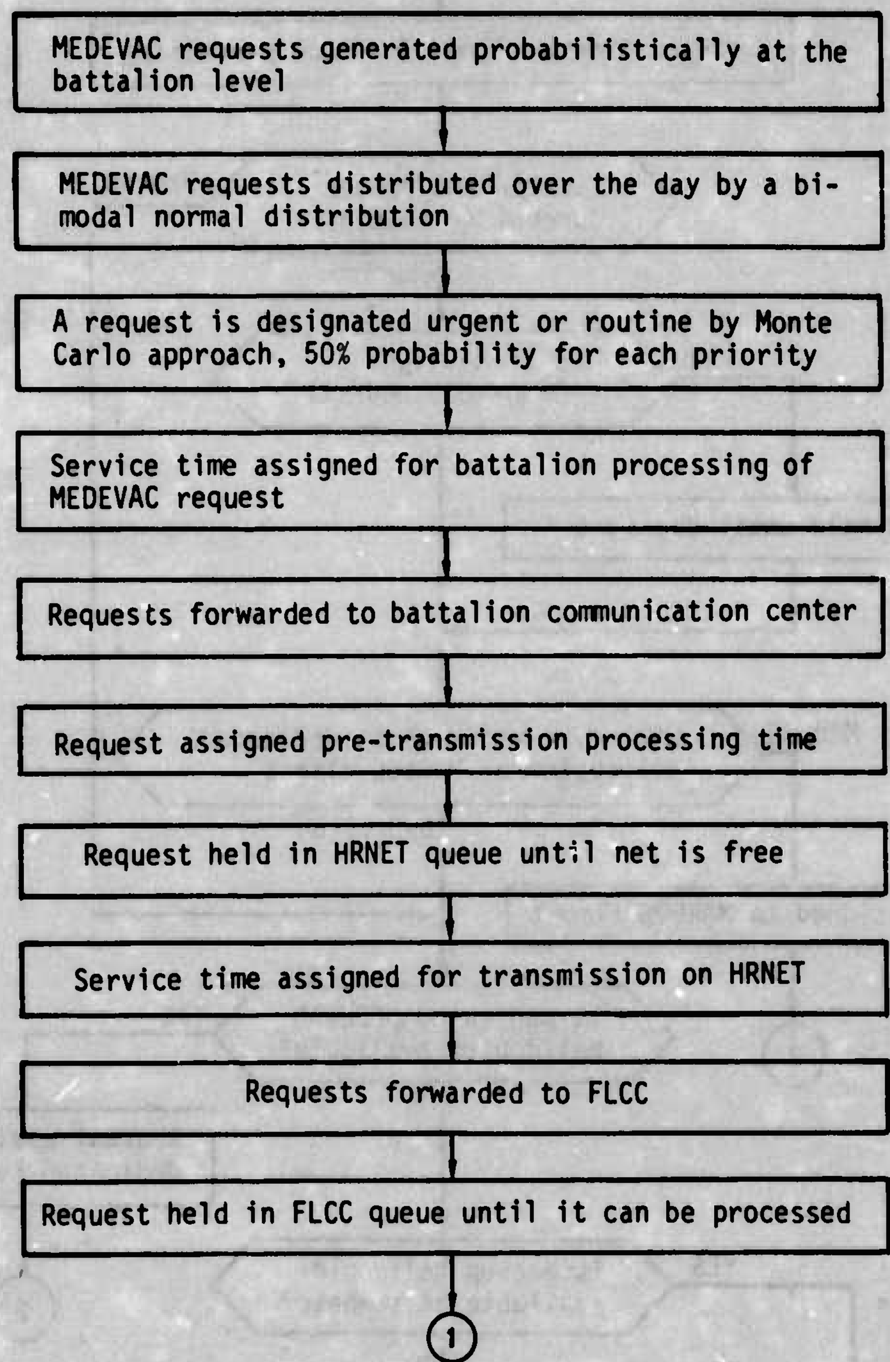
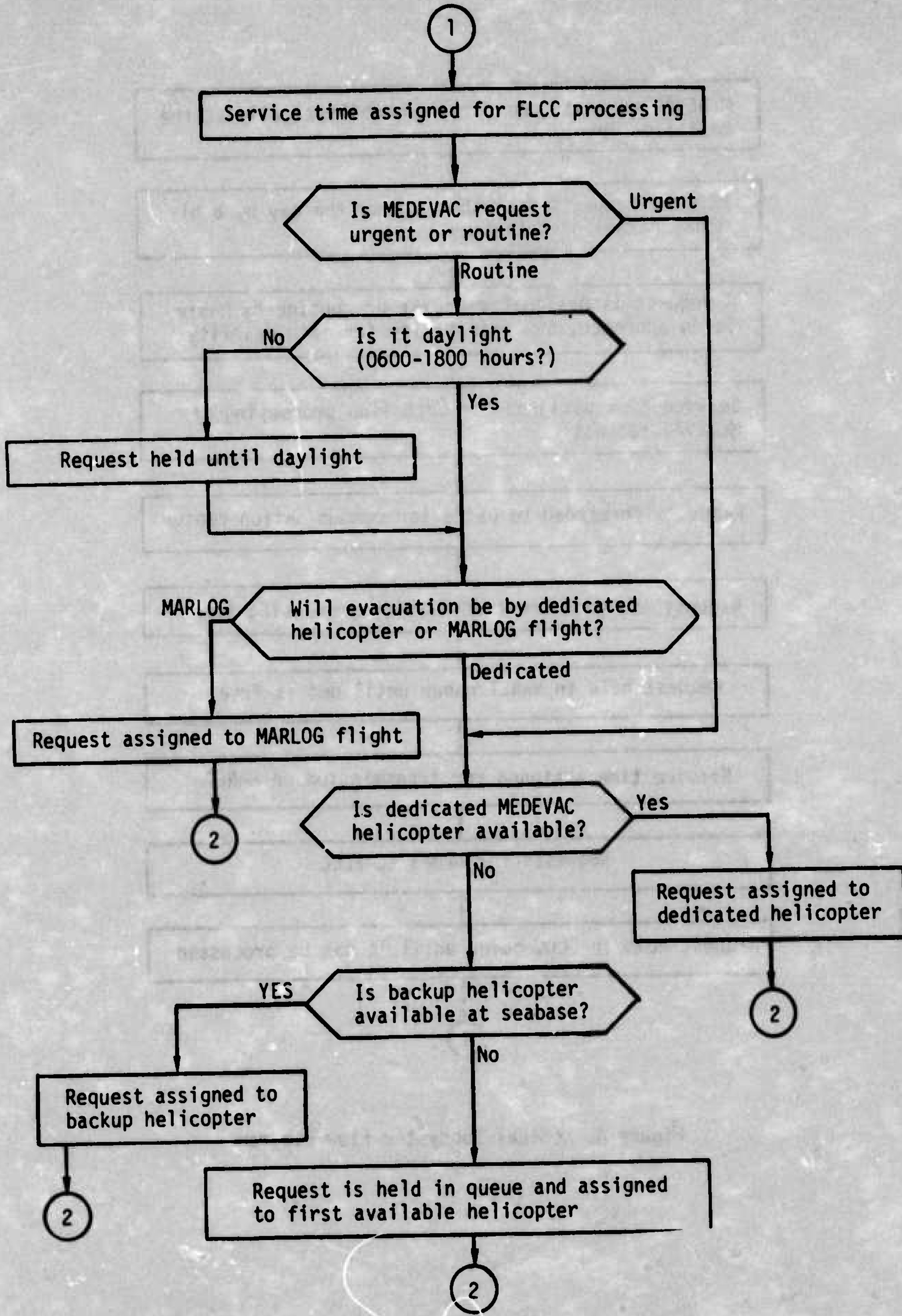


Figure 4. Medical Subsystem Flow Diagram



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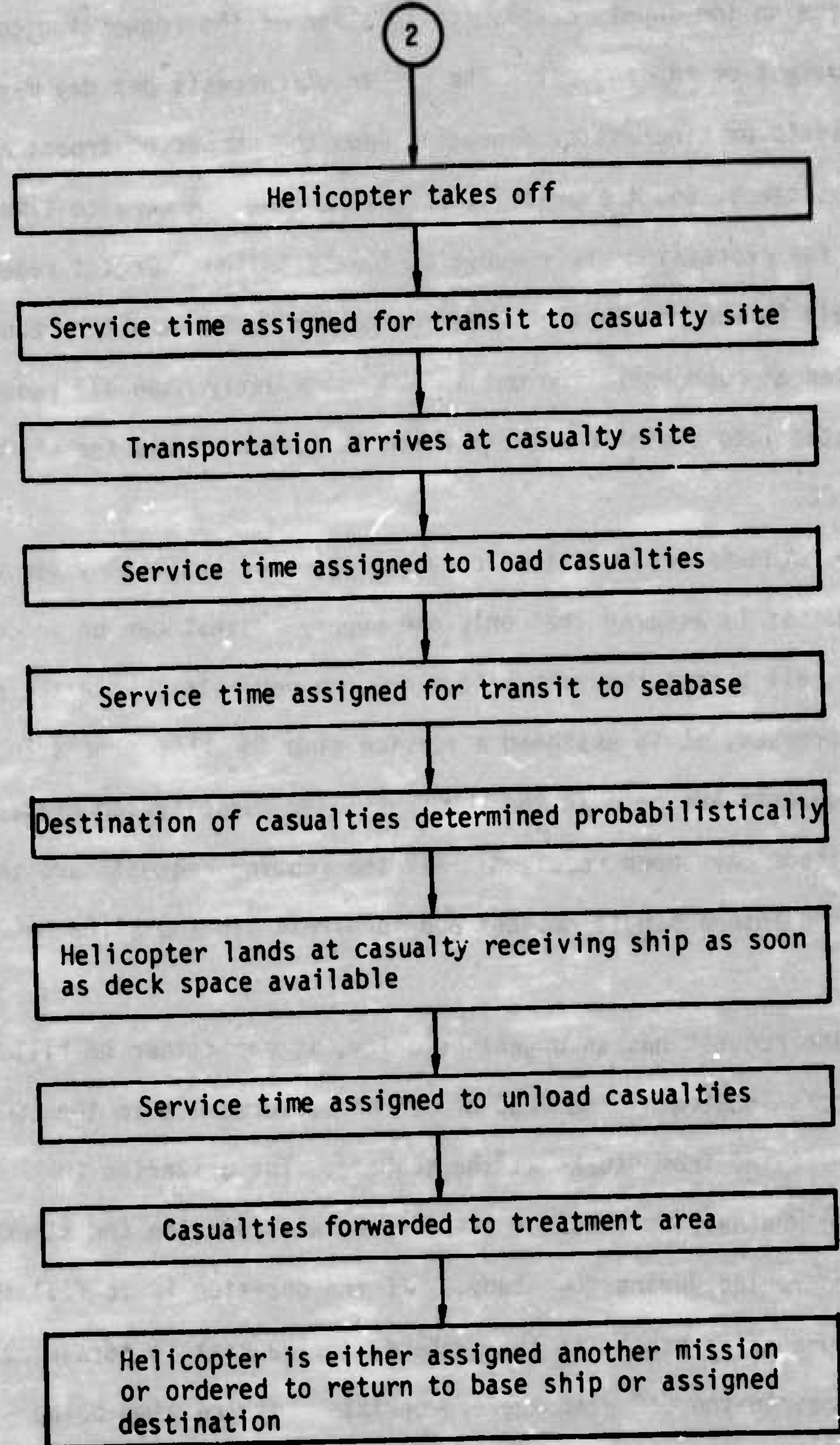


Figure 4 (cont)

information on the supply class, the location of the requesting company, and the weight of the request. The number of requests per day may be deterministic or stochastic, depending upon the number of troops ashore, the combat tempo, and the priority of the request. A service time is assigned for processing the request at the battalion. Urgent requests are immediately forwarded via the LFLOG net to the FLCC. Routine requests are accumulated at each battalion until 1600 hours daily when all requests are consolidated into a single request which is forwarded via the LFLOG net to the FLCC.

The requests are held in a queue at the FLCC until they can be processed. It is assumed that only one supply request can be processed at a time, all urgent requests before routine requests. When the request can be processed, it is assigned a service time for FLCC processing. Routine requests are held at the FLCC until the consolidated requests from all battalions have been received. All the routine requests are then consolidated into a single request and forwarded via the SBLOG net to the LSC.

If the request has an urgent priority, it can either be filled from safety stocks located at the FLCC or it can be forwarded to the LSC where it will be filled from stocks at the seabase. The criterion for determining whether the FLCC or the seabase will provide the stocks was a parameter varied during the study.[5] If the decision is to fill the urgent request from stocks at the seabase, the request is forwarded via the SBLOG net to the LSC with the appropriate service time being assigned. When the decision is to use safety stocks, a service time is assigned to break out the supplies and make them ready for delivery. While the supplies are being prepared, the delivery of the supplies is

arranged by the FLCC Transportation Coordinator. When the delivery vehicle arrives at the FLCC, it is assigned a service time for loading, a service time for transit to the requesting unit, and a service time for unloading. The supplies are then forwarded to the unit.

Requests forwarded to the LSC are held in a queue until they can be processed. When the LSC can process a request, a service time is assigned representing LSC processing time. During the processing, the LSC Supply Coordinator determines which ships of the seabase will provide the supplies and what types and quantities will be drawn from each ship. The LSC generates messages assigning the necessary actions to the various supply ships of the seabase. These messages are forwarded via the SBLOG net to the appropriate SLCC's.

A supply message is held in the SLCC queue until it can be processed. A service time is assigned for SLCC processing and then one for breaking out the supplies and making them ready for delivery. A message is then generated requesting the LSC to arrange transportation for the supplies. The transportation request is forwarded via the SBLOG net to the LSC and the appropriate transportation is arranged by the LSC (see Transportation subsystem, Section 3.5). When the vehicle arrives at the supply ship, it is assigned a service time for loading the supplies and a service time for transit to the requesting company. When the vehicle arrives at the company, it is assigned a service time for unloading and the supplies are then forwarded to the requesting company.

Figure 5 presents the Supply subsystem logic flow diagram.

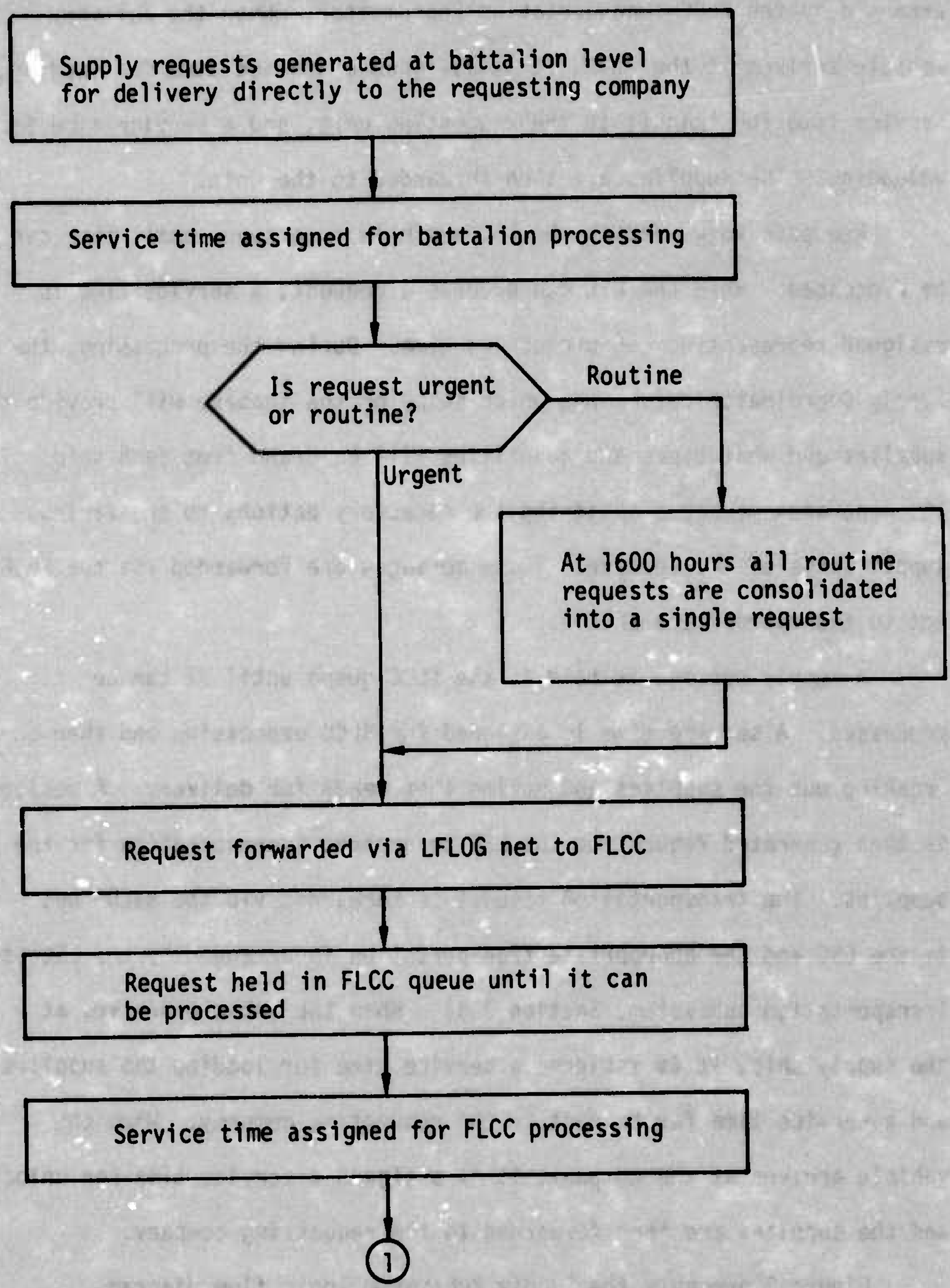
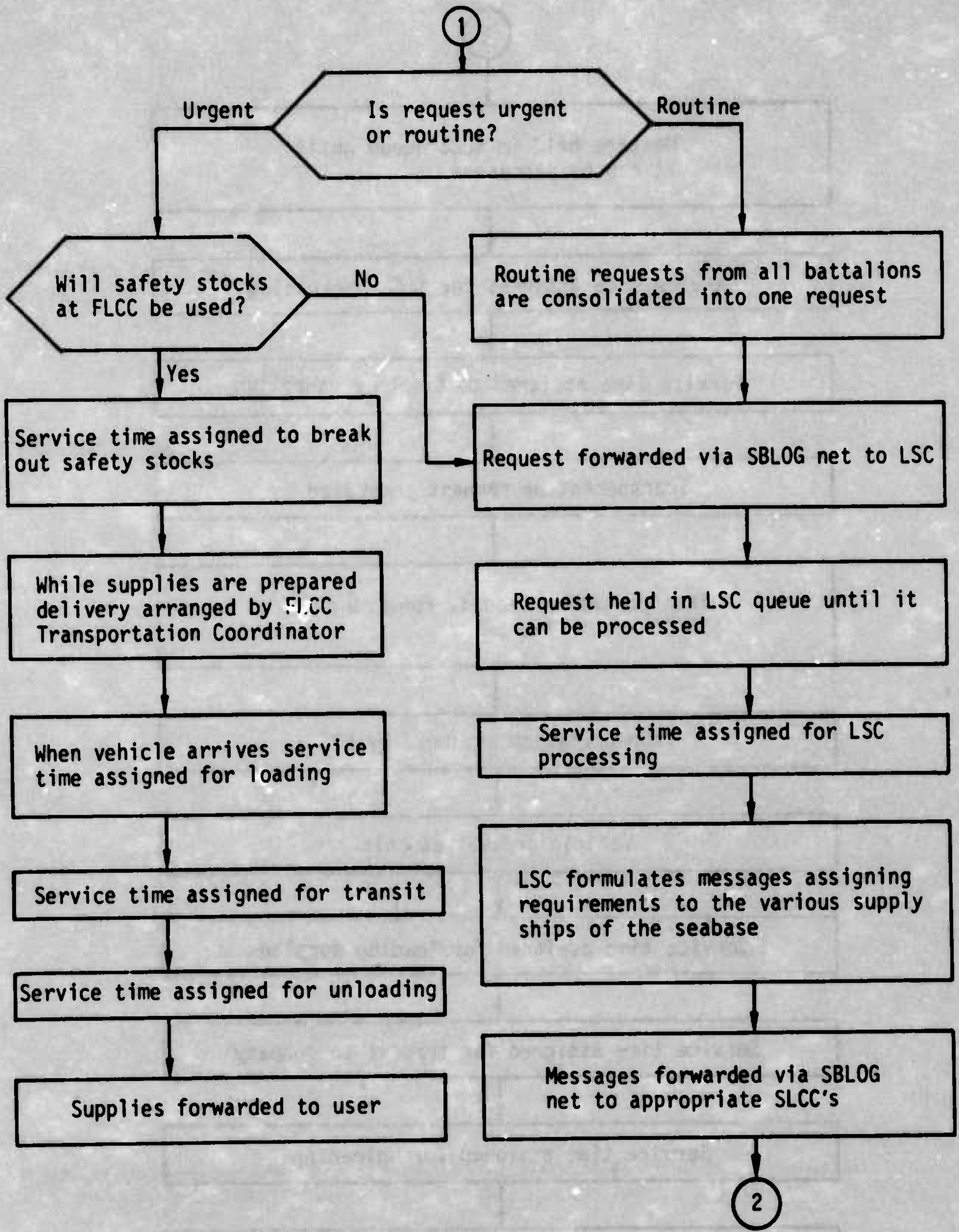


Figure 5. Supply Subsystem Flow Diagram



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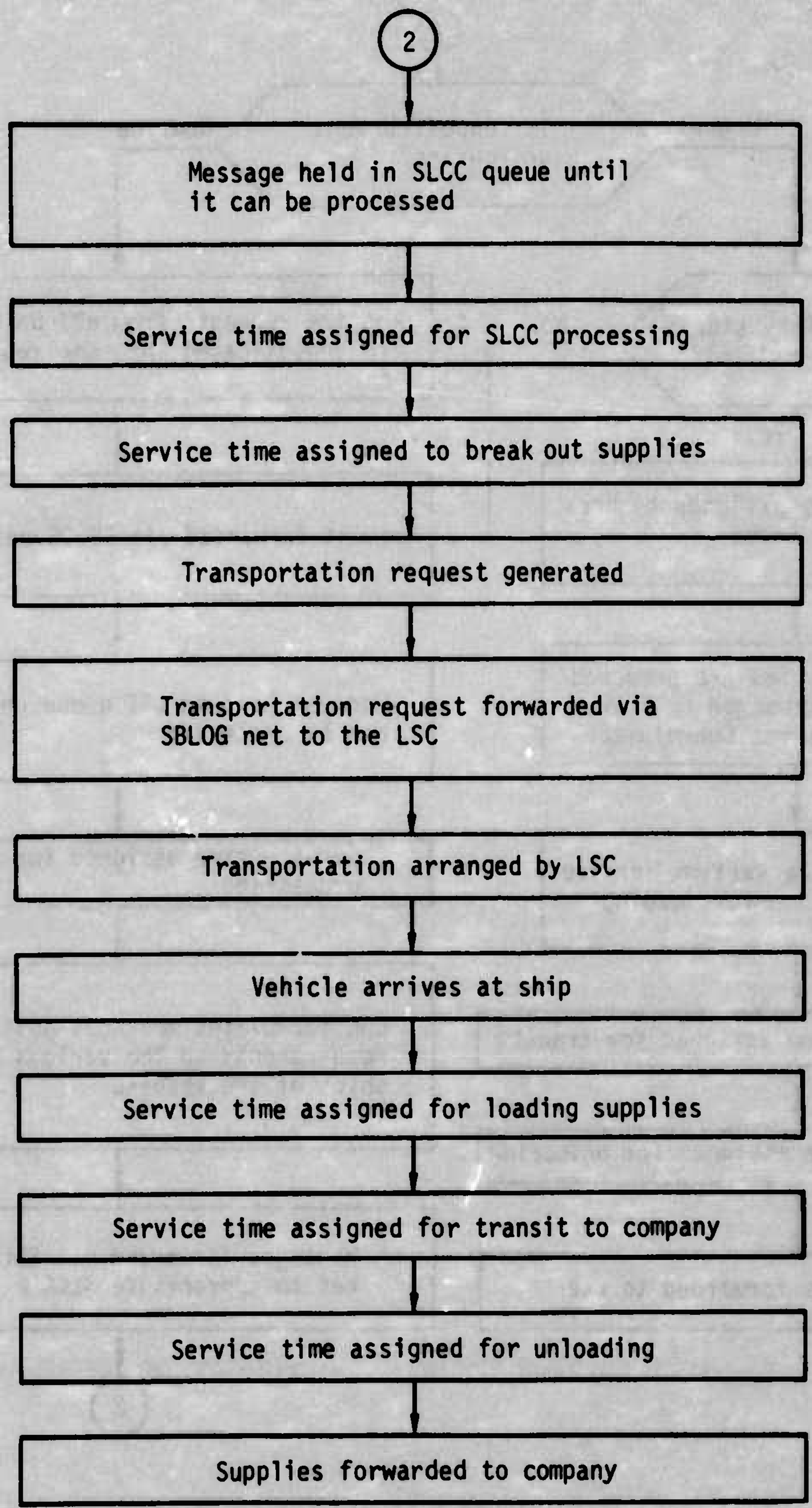


Figure 5 (cont)

3.4 MAINTENANCE SUBSYSTEM

3.4.1 Generation of Maintenance Requests

Item failures are generated probabilistically at the battalions, the BSA, and the FLCC. Because of model complexity and the large amounts of computer core required to simulate the concept, individual items are not identified in the model. All requirements and data are described by sub-commodity area; i.e., engineer, radio, teletype, LVT ordnance, tank ordnance, artillery ordnance, infantry ordnance, or motor transport. Each failure is probabilistically designated to a sub-commodity area.[5] However, each failure generated is followed in detail until the final action pertaining to the failure is completed.

The period of time during which an item may fail is restricted to the period of time during which the item is being utilized. This time period is determined for each sub-commodity area based on the usage of each individual item within the appropriate sub-commodity area. The echelon of repair, and the priority (either routine or urgent) are obtained from probability distributions developed from data pertaining to individual items.[5] The maintenance request submitted by each battalion therefore contains information on priority, repair echelon, sub-commodity area, and the location of the failure. Each maintenance request is assigned a service time for processing at the unit.

If the unit possesses second-echelon maintenance capability, a service time is assigned for diagnosis of the failure. If the repair can be performed immediately by unit personnel, a service time is assigned for repair and the item is returned to the unit. If the repair cannot be performed immediately by unit personnel a maintenance request message is formulated.

If the units do not possess second-echelon maintenance capability, a probabilistic determination is made as to whether or not the user can diagnose the failure. This diagnosis occurs when the failure is obvious; e.g., a broken fan belt. A maintenance request message is now formulated. If the failure is not at the FLCC the message is transmitted via the LFLOG net to the FLCC.

3.4.2 FLCC Actions and Contact-Team Assignment

The maintenance request is held in the FLCC queue until it can be processed and is then assigned a service time for processing by the FLCC. If support from the seabase is not required, the request is assigned for diagnosis and repair to a contact team of appropriate type if one is available. If a suitable contact team is not available, the request is held in a queue until a contact team becomes available. The priority scheme for assigning contact teams is as follows:

- Urgent job for which parts (which were available at the seabase) have arrived at the failure site
- New urgent job
- Routine job for which parts (which were available at the seabase) have arrived at the failure site
- New routine job

Within each priority, the job which has been waiting in the queue the longest will be handled first. A policy of dispatching a contact team to diagnose the failure was implemented to eliminate incorrect repair/replace/discard decisions at the LSC, based on an inaccurate description of the problem by inexperienced equipment operators.

When a contact team is assigned, it travels to the failure site and begins repairing the item. Contact teams are able to repair during daylight hours only. In the model it was assumed that this period extended from 0600 to 1800 hours. It was further assumed that a contact team may be assigned a job at any time during this period (when not previously engaged in an assignment), and will rest only between assignments. Coordination of contact teams is performed by the FLCC. If transportation is required, it is arranged by the FLCC Transportation Coordinator. Orders are formulated and transmitted via the LFLOG net to the contact team if the contact team is not at the FLCC. Contact teams at the FLCC are informed orally of the assignment.

If the request requires support from the seabase, the FLCC forwards the request via the SBLOG net to the LSC. These requests require either repair parts which are located at the seabase, evacuation of the item to the seabase for repair, or (when the units possess 2nd echelon repair capability) assignment of a contact team located at the seabase.

3.4.3 Contact-Team Diagnosis and Repair

After the contact team has received its orders, it awaits the arrival of a transportation vehicle. When the vehicle arrives, it is assigned a service time for loading the contact team and one for transit to the failure site. When the vehicle arrives at the failure site, it is assigned a service time for unloading. The contact team then conducts the failure diagnosis during a service time assigned for this act. If the failure is not repairable by a contact team, a message requesting evacuation of the item to the seabase is formulated, as is a message of contact team availability. These messages are transmitted to the FLCC either orally or via the LFLOG net.

The requirement for repair parts from the seabase is determined probabilistically.[5] If the contact team can complete the repair without repair parts from the seabase, a service time is assigned for the repair. A message is then generated notifying the FLCC that the repair is completed and that the contact team is available. The message is transmitted to the FLCC either orally or via the LFLOG net.

If repair parts are required from the seabase, a message is generated requesting the repair parts and also notifying the FLCC that the contact team is available. The message is transmitted either orally or via the LFLOG net to the FLCC.

The messages are held in the FLCC queue until they can be processed. A service time is assigned for FLCC processing. Requests for repair parts or for evacuation of items to the seabase are forwarded via the SBLOG net to the LSC.

The FLCC determines whether the contact team should be assigned to another mission. If the availability message is received during darkness (1800 - 0600 hours), it is held until 0600 hours. If a job of the same commodity area is awaiting assignment, the contact team is assigned that job. If more than one job of the same priority is awaiting assignment, the job which has been in the queue the longest is chosen. All urgent jobs are assigned before any routine jobs. If no jobs are in the queue, the message of contact team availability is held at the FLCC until a job occurs.

3.4.4 LSC Processing

Messages which arrive at the LSC are held in a queue until they can be processed. A service time is assigned for LSC processing and message

formulation. Processing by the LSC involves deciding what action will be taken on each type of request. The messages consist of requests for repair parts and/or contact teams, for evacuation of a failed item to the seabase for repair, for issue of a replacement item, and/or for return of a repaired item to the unit. Once a decision has been made, messages are formulated notifying the appropriate coordination centers of the action taken.

3.4.5 Repair Parts Required by Contact Teams

When the LSC processes a request for repair parts, it determines whether the parts are available at the seabase or whether they must be obtained from outside the seabase. This information is obtained from a probability distribution which reflects the percentage of time parts are available. If the parts are available in the seabase, transportation is arranged and a message is generated ordering the appropriate SLCC to prepare the parts for delivery. This message is forwarded from the LSC to the SLCC via the SBLOG net. If parts are required from outside the seabase, the item will be repaired in the maintenance shops at the seabase when the parts arrive. The process of ordering and supplying parts from outside the seabase is simply simulated by the assignment of a suitable deterministic service time.[5] The procedures for repair in the maintenance shops and for sending a replacement item are discussed in Sections 3.4.6 and 3.4.8.

The message is held in the SLCC queue until it can be processed. A service time is then assigned for processing and the item is then prepared for delivery. When the transportation vehicle arrives, it is assigned a service time for loading, one for transit to the unit, and one for unloading. The repair part is then forwarded to the unit.

If the units possess second-echelon maintenance capability, either unit maintenance personnel or a contact team completes the repair. If a contact team is required the model assumes it is delivered from the seabase with the repair part. A service time is assigned representing repair time. The repaired item is then returned to service and the contact team, if one was used, returns by MARLOG flight to the seabase.

If the units do not possess second-echelon maintenance capability, a request is formulated requesting a contact team to complete the repair. After a service time for processing, the request is forwarded via the LFLOG net to the FLCC where it is held in a queue. The procedures for assigning a contact team were discussed in Section 3.4.2.

3.4.6 Replacement from Operational Readiness Float (ORF)

If the LSC determines that repairs are to be performed in the maintenance shops at the seabase, a decision must be made as to whether a replacement should be drawn from the Operational Readiness Float (ORF). A probability distribution reflecting ORF availability for each subcommodity area is used to determine whether a replacement is available at the seabase. If it is, the decision to send the replacement is made by considering the priority of the request, the subcommodity area, and the anticipated downtime. If the anticipated downtime for the failure is greater than the acceptable maximum value, the ORF (float) item will be sent. The Maintenance Optimization Model[7] was used to develop probability distributions, based on these considerations, for use as input[5] in the current model.

7 Van Eseltine, C., "Seaborne Mobile Logistic System (SMLS) Maintenance Optimization Model, Version II - User's Manual," NSRDC report 4381, Mar 1974.

If a replacement is required, the LSC will arrange transportation either by helicopter or by boat. Once the transportation mode is indicated, a message is formulated and sent via the SBLOG net to the SLCC located aboard the ship where the ORF item is stored, ordering the item to be prepared for transportation pickup. Upon the arrival of the message, a service time reflecting the time to locate, move, and stage the item for transport to the requesting battalion ashore is assigned. When the specified means of transportation arrives, a service time is assigned for loading the vehicle. Then a service time is assigned for delivering the replacement to the battalion where the failure occurred. When the vehicle arrives at the unit, it is assigned a service time for unloading and the item is then forwarded to the unit.

3.4.7 Evacuation of Failures to Seabase

If the failed item is to be evacuated to the seabase for repair, the LSC must designate the ship on which the repair is to be performed. In the simulation model, the LPD's are configured to function as maintenance support ships for the ATG/MAB. The model has been designed so that maintenance facilities for each sub-commodity area may be centralized on one ship or dispersed among the maintenance support ships.

If the priority of the original request was urgent and a replacement was sent, the priority for evacuation and repair of the failed item is changed to routine. Otherwise, the priority of the initial request is retained.

The LSC arranges the necessary transportation to evacuate the failed item to the seabase. A message is then formulated notifying the unit to prepare the item for transit to the seabase. This message is forwarded

via the SBLOG net to the FLCC where it is held in a queue until it can be processed. A service time is assigned for FLCC processing. If the failed item is located at the FLCC, the message is passed orally to the users; otherwise, the message is transmitted via the LFLOG net to the battalion or the BSA. A service time is assigned for battalion or BSA processing of the message and for preparing the item for transit. When transportation arrives, the vehicle is assigned a service time for loading and one for transit to the seabase. When the vehicle arrives at the seabase, it is assigned a service time for unloading. The item is then forwarded either to the shop queue to await repair or to a storage area until the necessary parts are available. A service time is assigned for this movement.

3.4.8 Repair of Items in the Seabase

In the model, shop queues are established for each maintenance shop in the seabase. The queue represents the location aboard the ship where the item is stored while waiting entrance to the shop. Within a given priority category, the job which has been in the queue the longest will enter the shop when space is available. Urgent jobs are all processed before any routine jobs. The number of shop spaces for each sub-commodity area is specified in the model input. The following priority scheme has been established for repair in the seabase maintenance shops:

1. Urgent job for which repair parts have arrived from outside the seabase
2. New urgent job
3. Routine job for which repair parts have arrived from outside the seabase

4. New routine job

It is assumed that each shop is in operation 24 hours per day and has sufficient maintenance personnel available to operate continuously at full capacity.

If the failed item is one which has not been diagnosed, it is first assigned a service time for diagnosis. If all assets necessary for repair are available, the item is assigned a service time for repair. If all assets are not available, the failed item is stored and a message is formulated notifying the LSC that the item cannot be repaired immediately. This message is forwarded via the SBLOG net to the LSC and the LSC determines whether an ORF item should be sent to the unit.

When the repair is completed, the repaired item is returned to the ORF if a replacement item was issued. If an ORF item was not sent, a request for transportation is formulated. The repaired item is moved to the staging area and the transportation request is forwarded via the SBLOG net to the LSC where transportation is arranged.

3.4.9 Second-Echelon Repair Capability by Unit Maintenance Personnel

The model has been developed to also permit the testing of second-echelon maintenance capability at the units. Under this policy, all maintenance failures are diagnosed by unit maintenance personnel. It is assumed that every diagnosis is correct. Based on data received from the SMLS Study Panel at MCDEC, all second-echelon failures can be repaired by unit maintenance personnel with the exception of radio and teletype failures of which only 40% are repairable at the unit due to requirements for special equipment and facilities. The procedures for handling repair parts do not change when second-echelon repair capability is given to the units.

The requirement for a contact team for third-echelon failures may be determined by unit maintenance personnel. This decision is obtained in the model from a probability distribution. With second-echelon repair capability at the units, contact teams are stationed at the seabase. The contact teams will be transported ashore with any repair parts required. Once the repair is completed, the contact team returns to the seabase via the next MARLOG flight.

The model logic flow for the Maintenance subsystem is shown in Figure 6.

3.5 TRANSPORTATION SUBSYSTEM

Transportation requests from all subsystems* are sent to the LSC to be assigned the proper type of transportation. Transportation assets available to SMLS include helicopters, landing craft, and trucks. The LSC decides which mode of transportation (surface or air) to use for a particular mission. A service time is assigned representing the time needed to determine the mode of transportation. Transportation requests designated for landing craft are forwarded via the SBLOG to the Primary Control Ship (PCS); those designated for trucks are forwarded to the FLCC; and requests for helicopters are held by the LSC until they can be compiled into helicopter loads. When helicopter loads have been compiled, the LSC notifies the Helicopter Control Section (HCS) which is responsible for the execution of the delivery.

Figure 7 shows the logic flow for the designation of the mode of transportation.

3.5.1 Transportation by Helicopter

Requests designated by the LSC for air transportation receive a

*Except MEDEVAC requests which are processed by the FLCC.

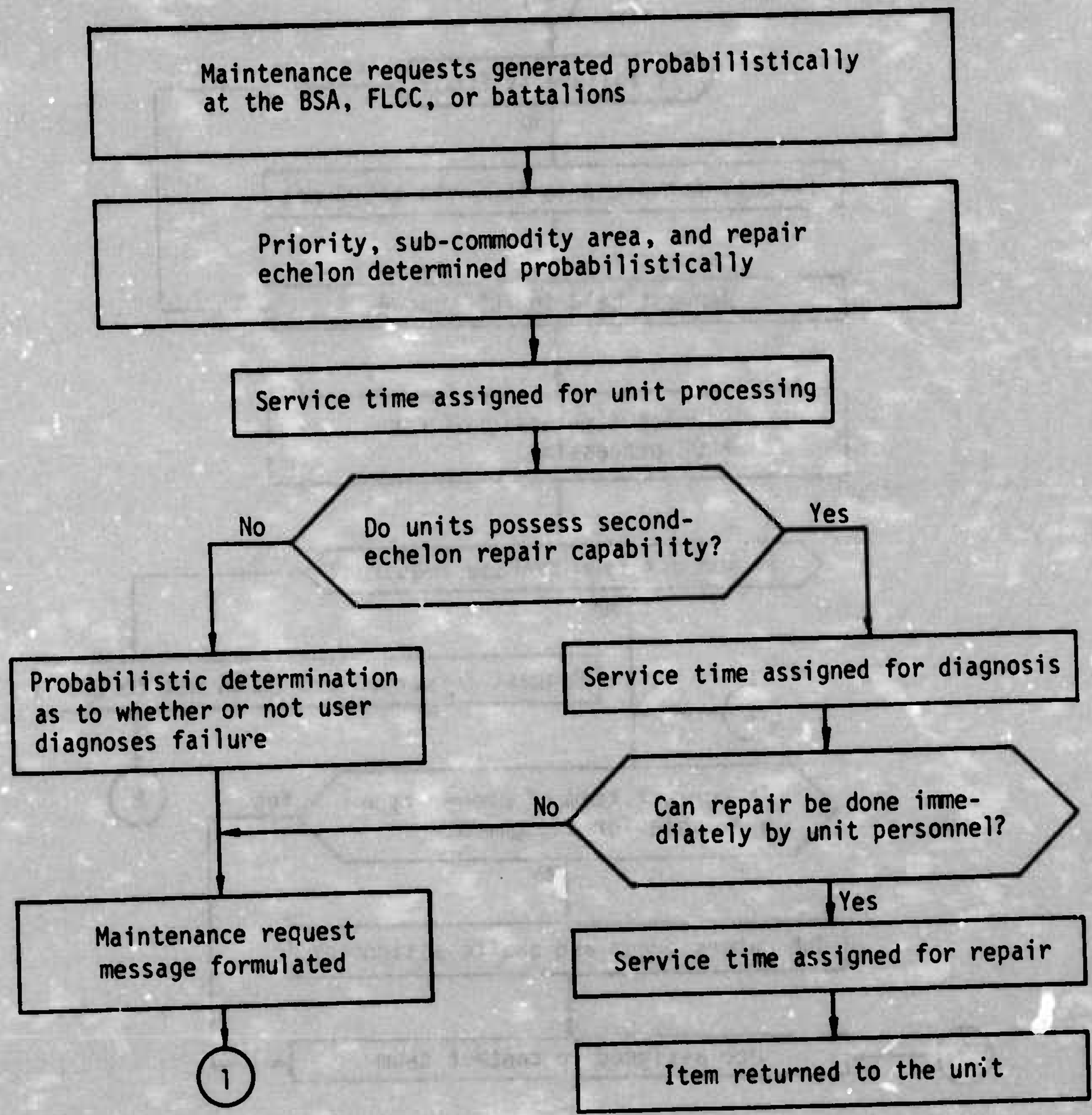
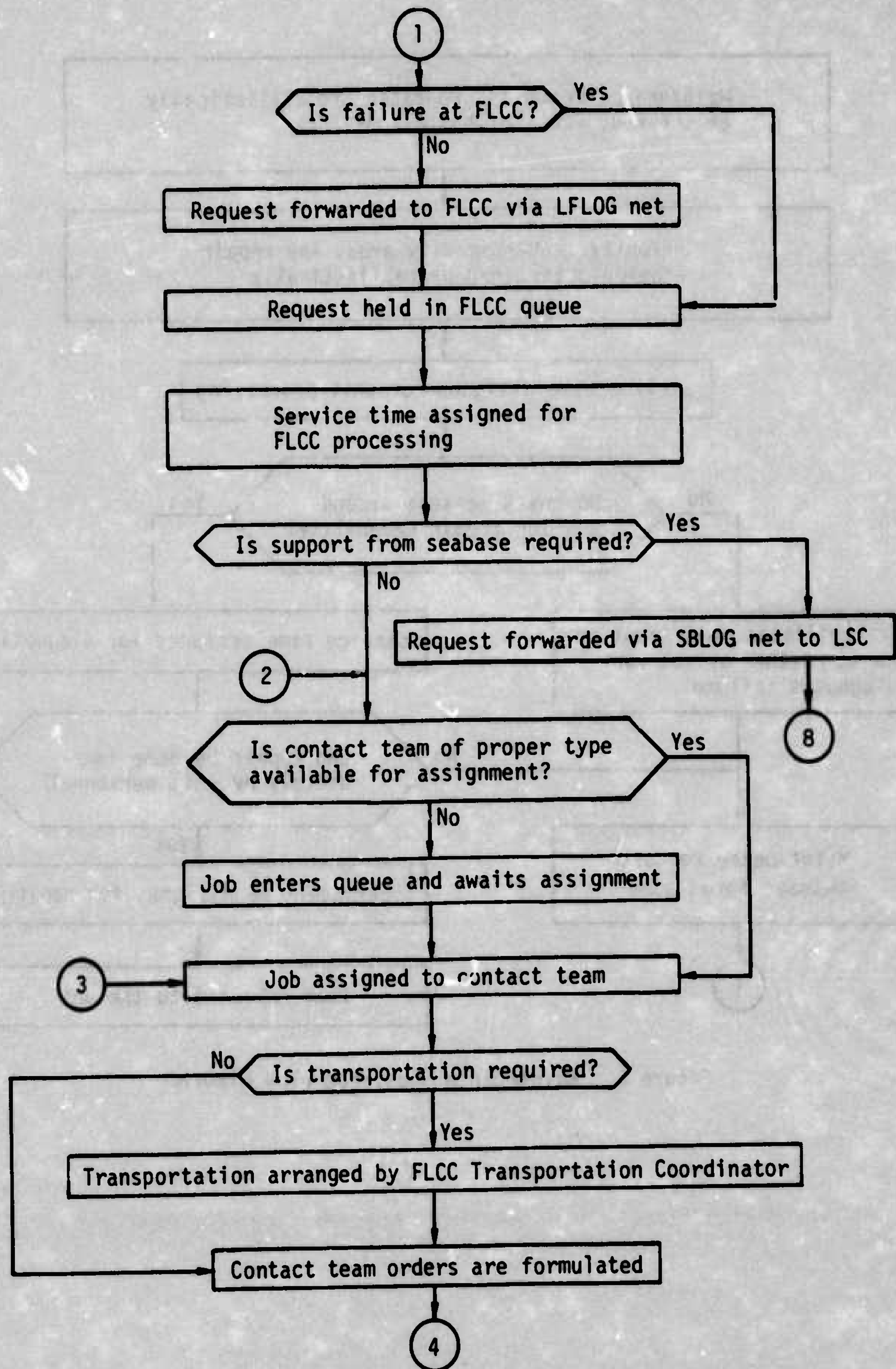


Figure 6. Maintenance Subsystem Flow Diagram



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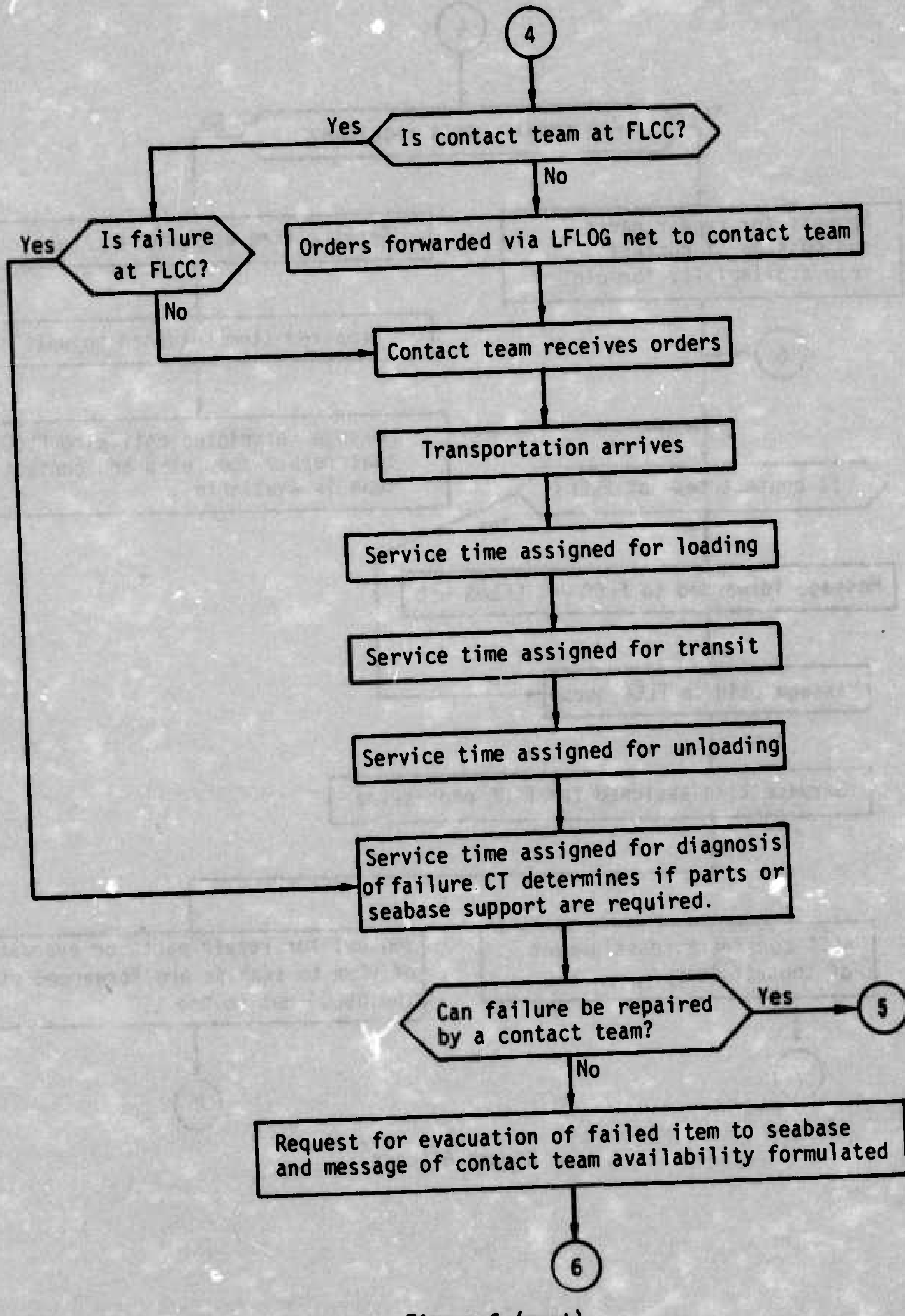

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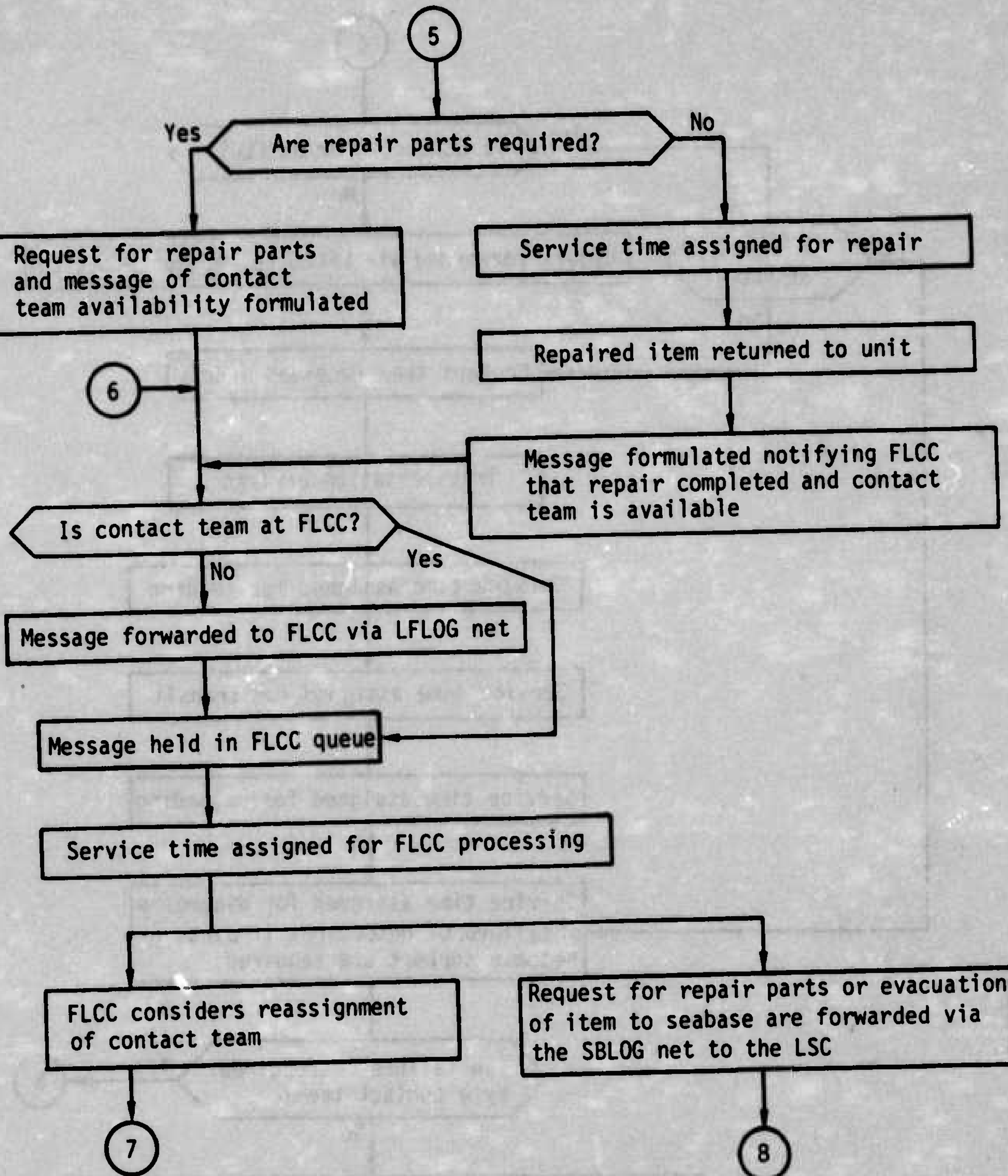

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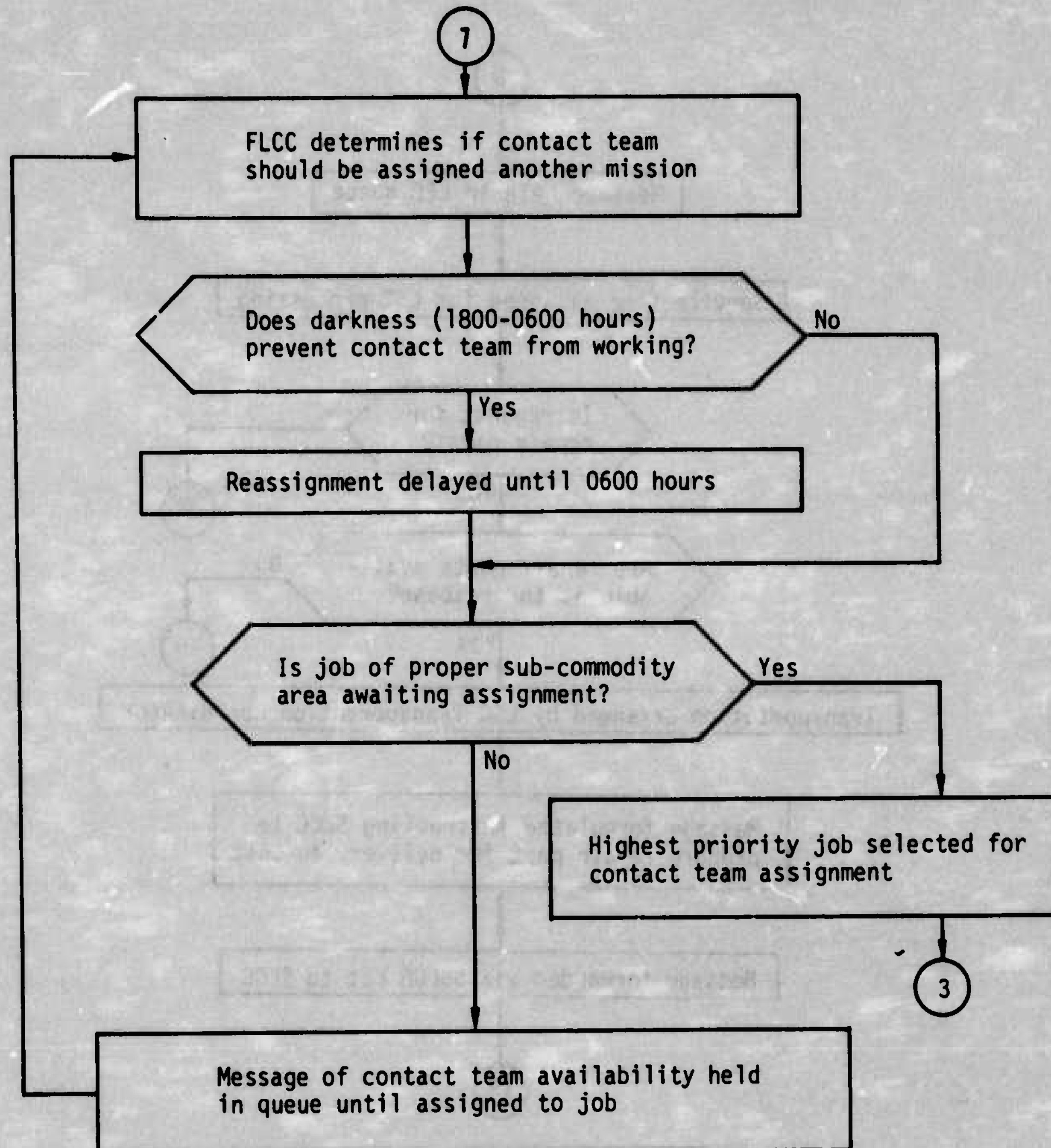

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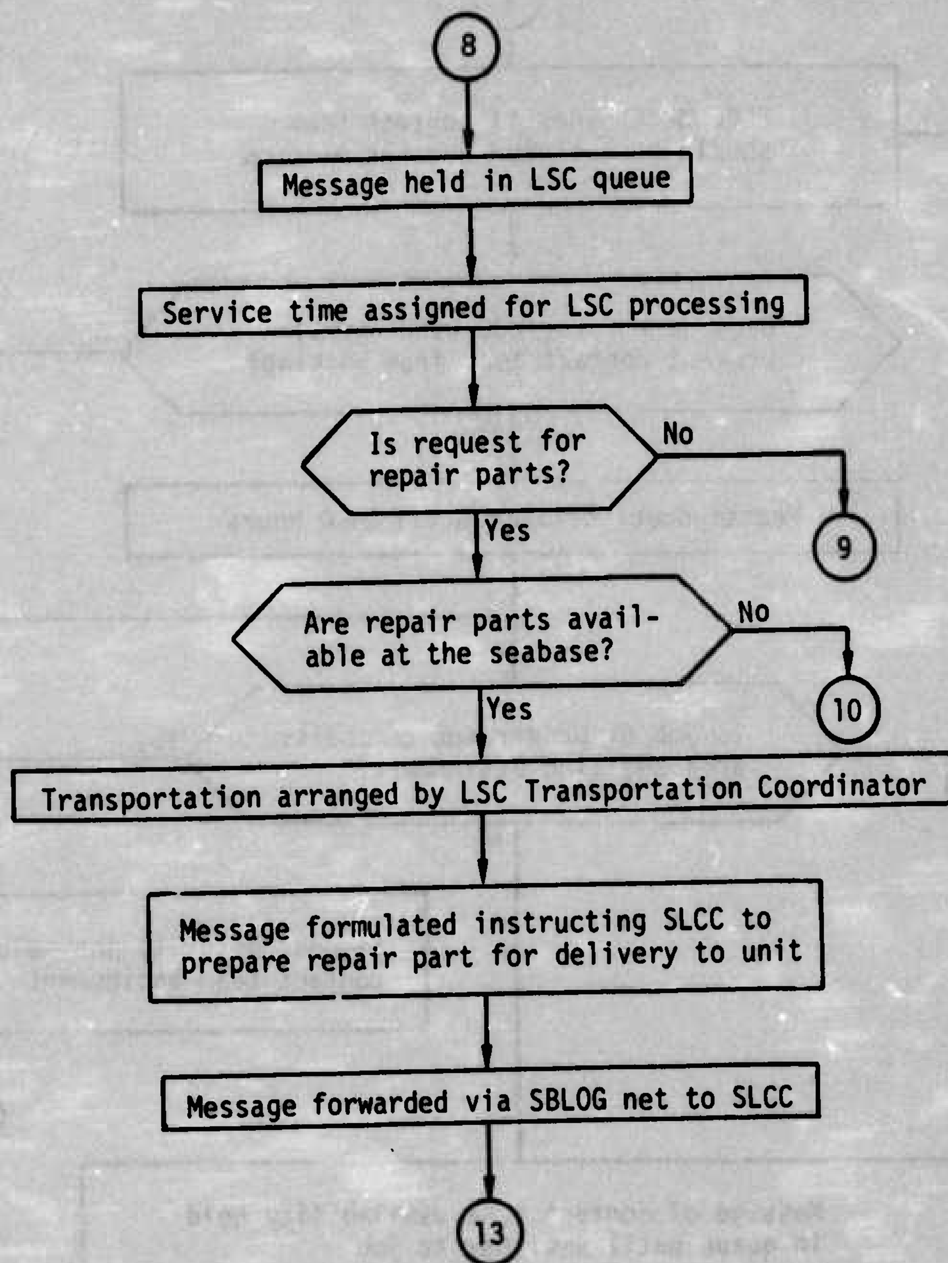

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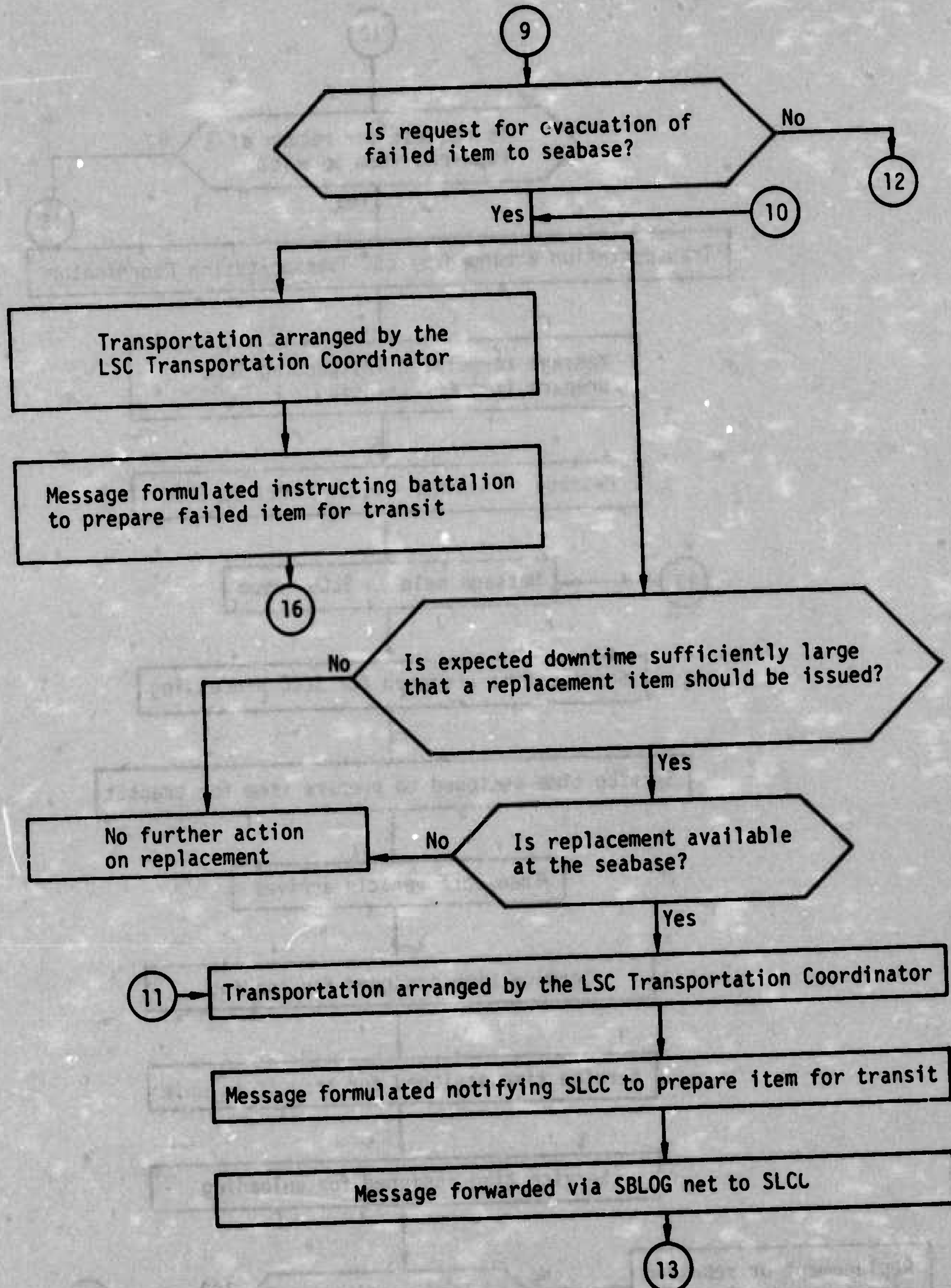

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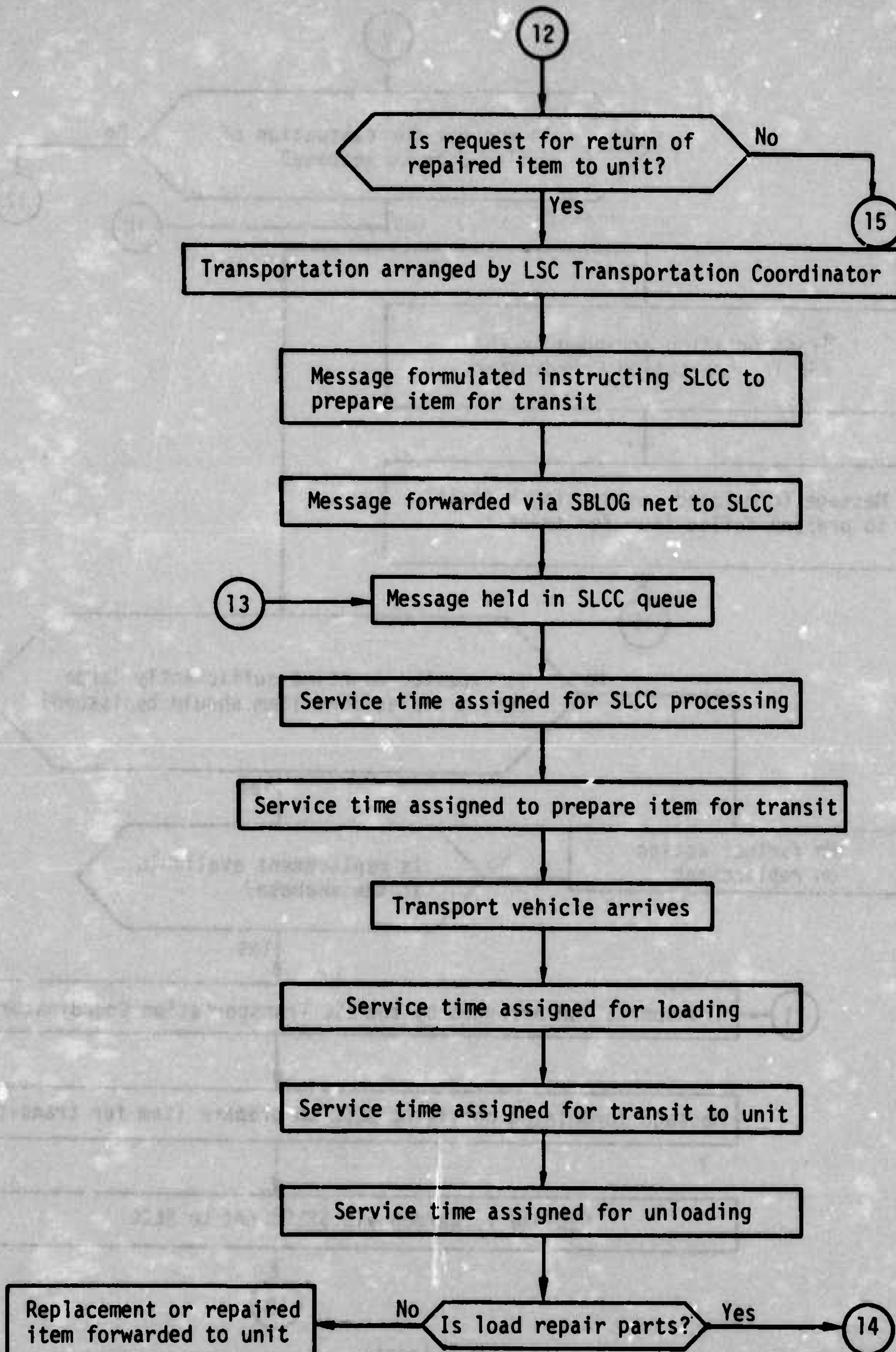

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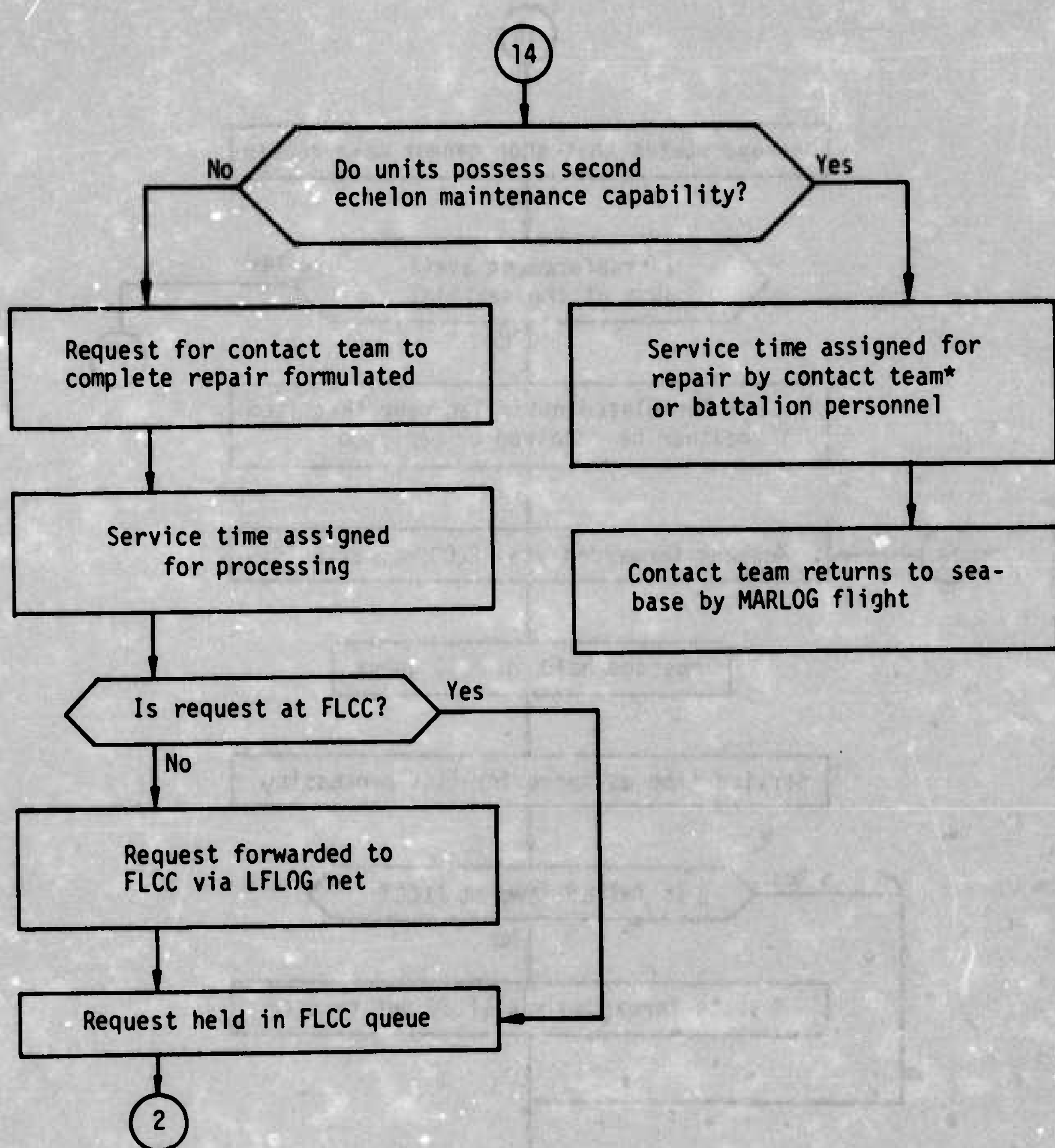
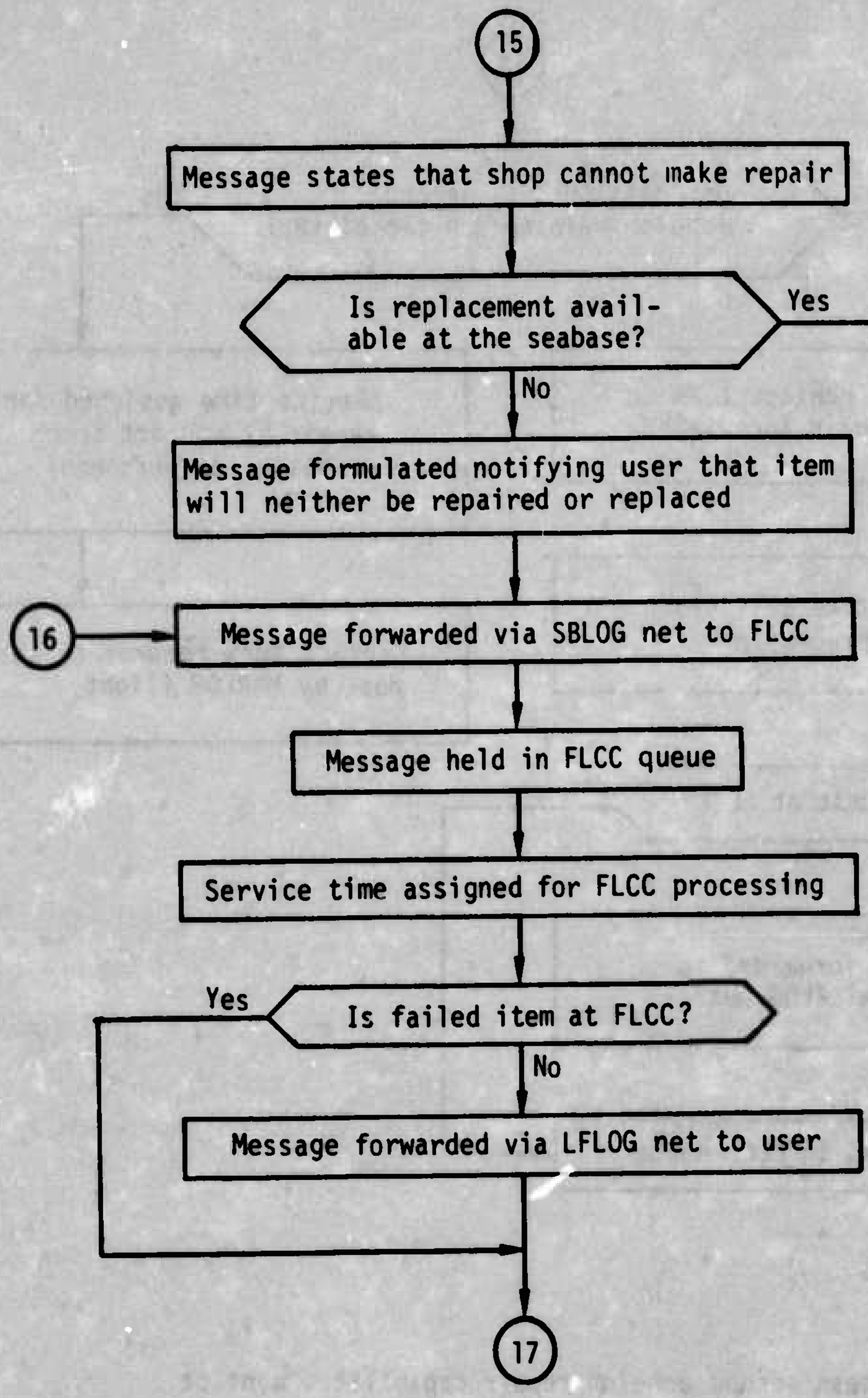


*When units possess second-echelon repair capability, contact teams are assumed to be delivered with the repair parts.

Figure 6 (cont)



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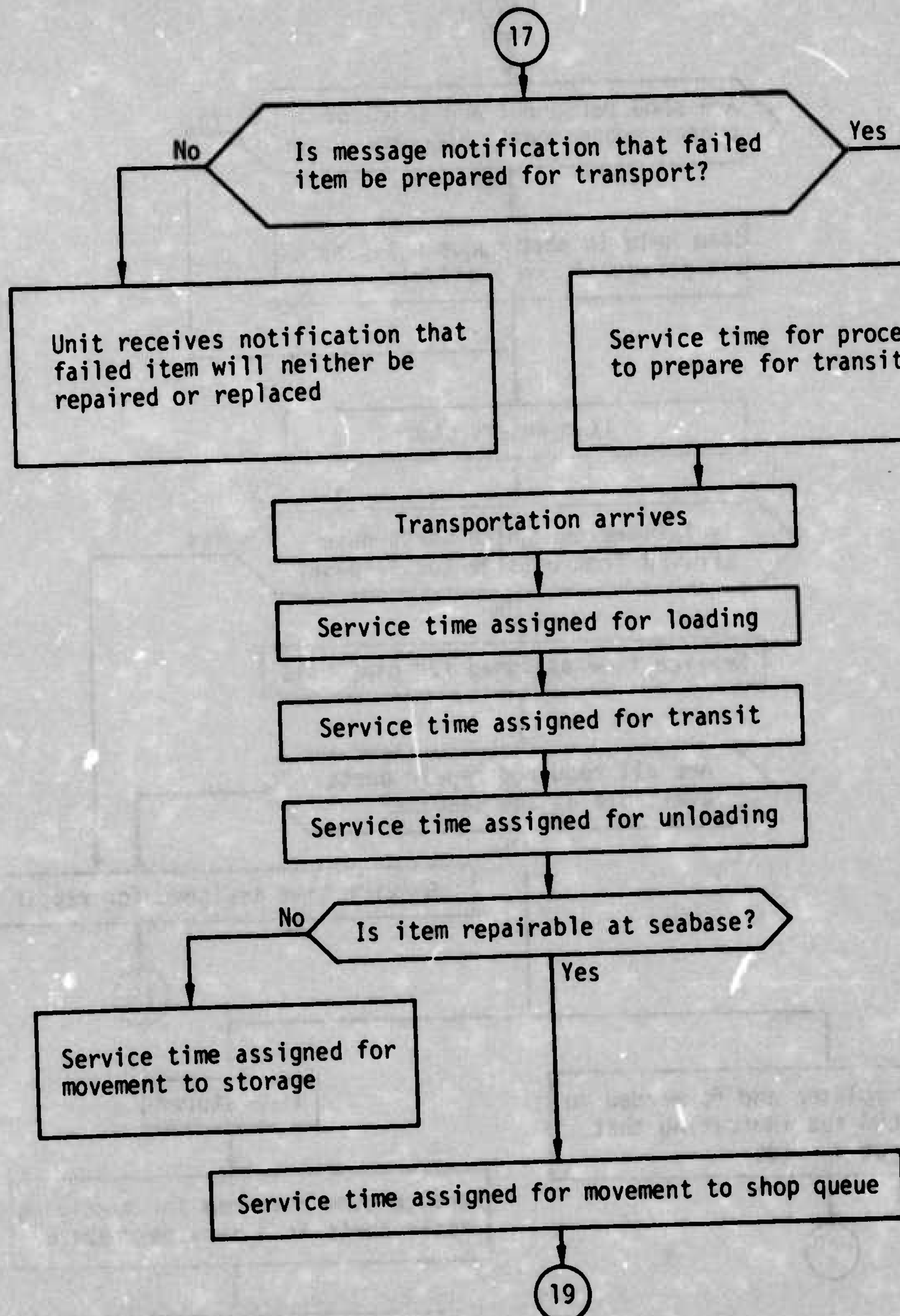

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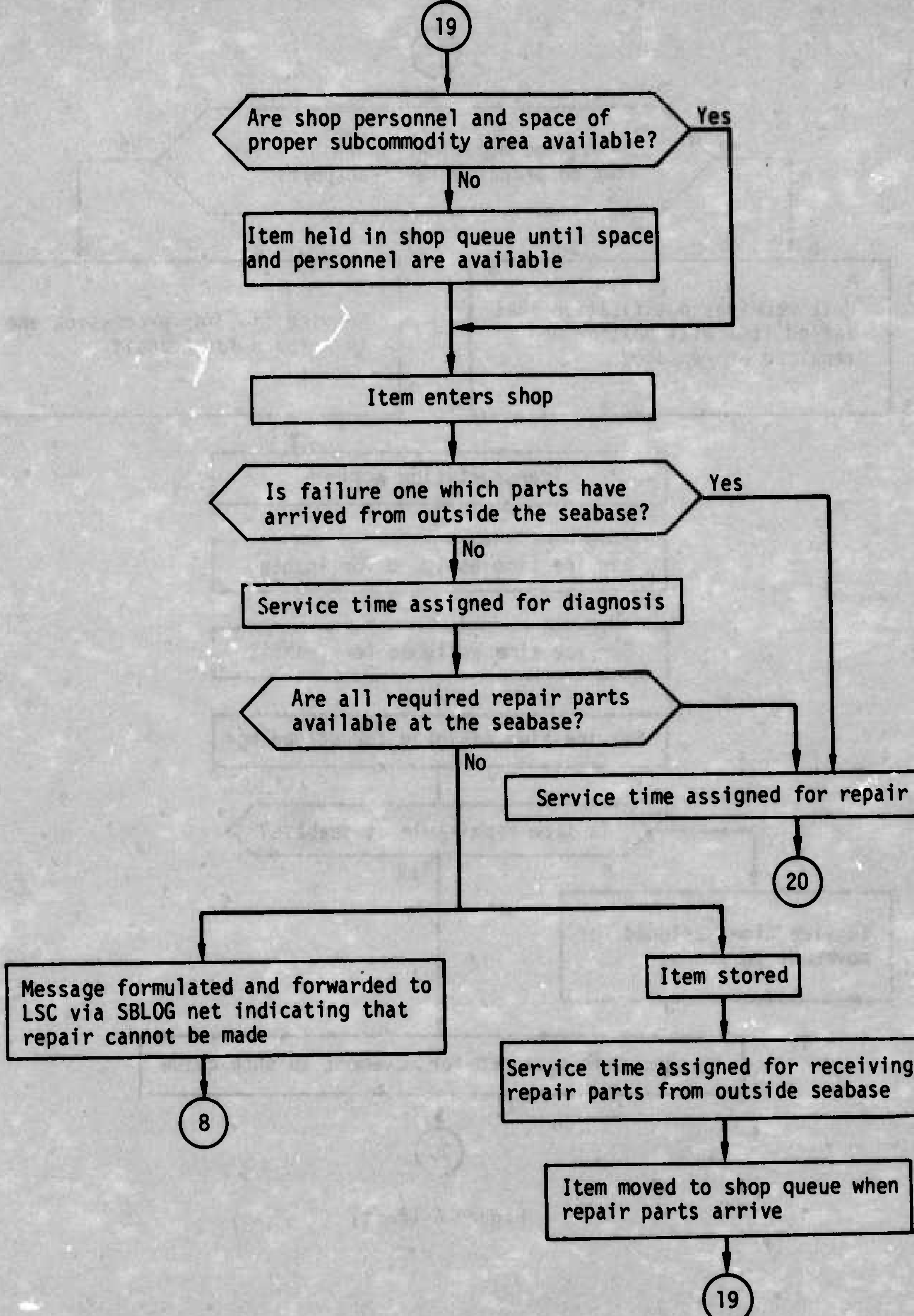

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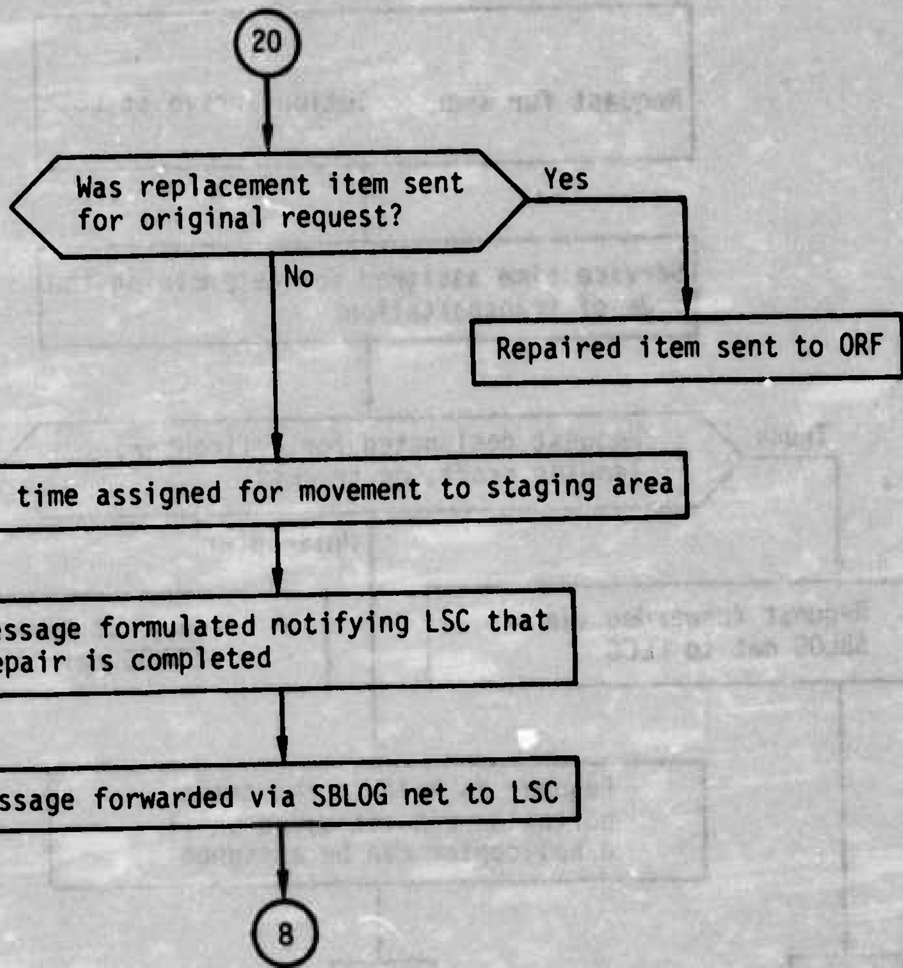

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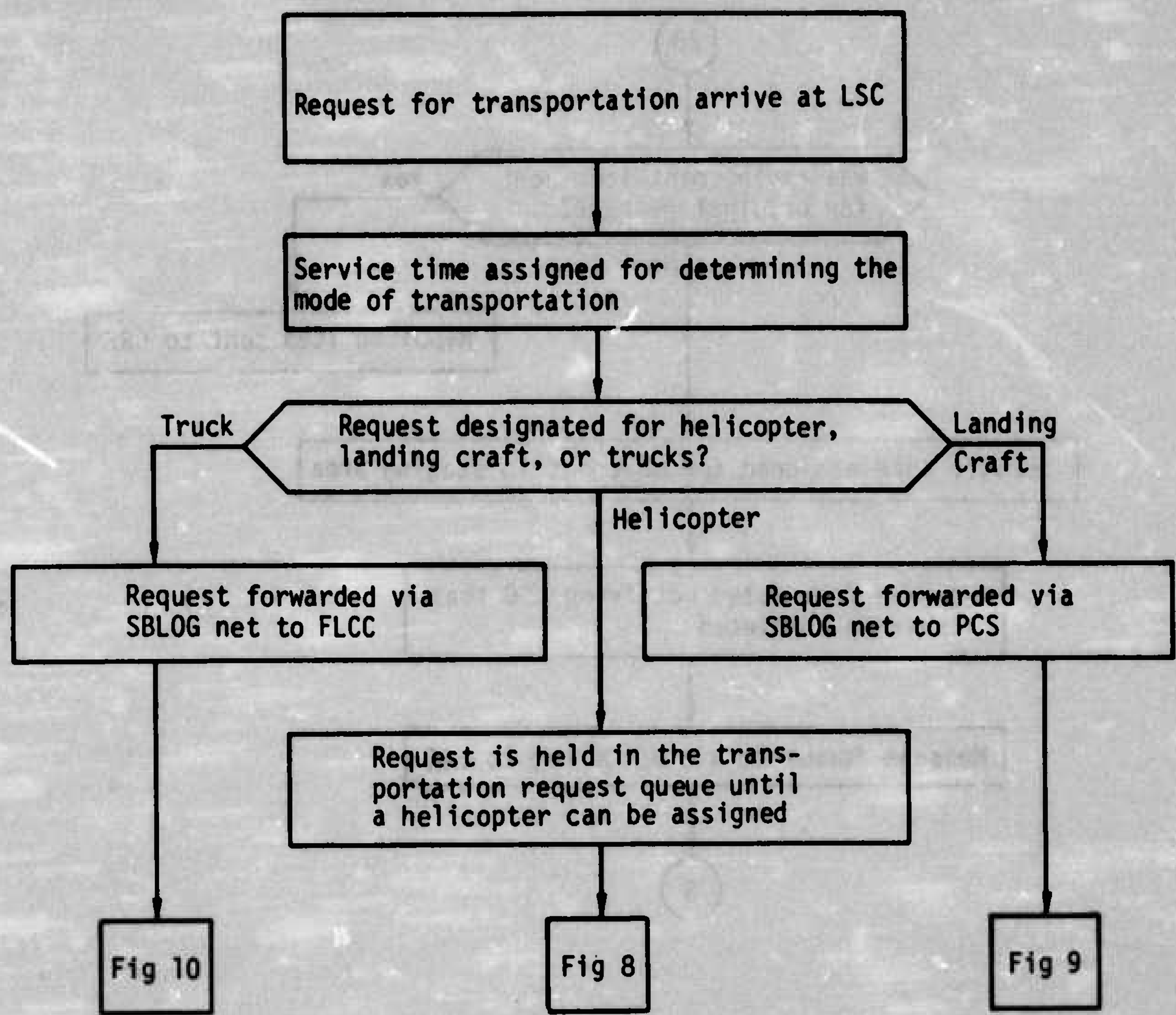


Figure 7. Designation of the Mode of Transportation

service time for processing at the LSC. If helicopters are not permitted to operate due to conditions such as inclement weather (the model can make this decision by a Monte Carlo process, or the analyst can insert a deterministic rule), requests from ashore which had been designated for helicopter transportation by the LSC are forwarded to the FLCC and requests from the seabase are forwarded to the PCS to obtain a surface mode of transport.

If conditions do permit helicopters to operate, the LSC checks the priority of the request. If a request is urgent, a message is generated instructing the HCS to perform the mission. The message contains the following information: priority, type of helicopter required (CH-46 or CH-53), type of load (internal or external carriage), and pickup and drop points of the load. The message is forwarded to the HCS. If the request is routine, the LSC determines whether the request is for internal or external carriage. If the carriage is external, the type of helicopter required is specified and a message is generated instructing the HCS to perform this mission. The message is then forwarded to the HCS.

If the request is for a routine internal load, it is held in the load queue. At specified intervals (e.g., hourly) the queue is checked and load orders are made up by pickup location. All requests at a particular pickup location are combined and assigned to the fewest number of helicopters which can carry the weight and volume of the requests. In designating the type of helicopter, the model selects that type which can most efficiently carry the requested load. In making up load orders, multiple drop points can be considered. When the load order is completed for a pickup point, a message is generated instructing the HCS to perform the mission. The message is forwarded to the HCS.

Load orders arrive at the HCS from the LSC and are assigned a service time for processing. The orders are separated by priority. Urgent orders are further separated as to whether the pickup point is ashore or at the seabase. If an urgent load order is from the seabase, it is assigned to a helicopter, capable of performing the mission, which completed a mission at the seabase. If no such helicopter is available, an urgent load order is assigned to a helicopter on alert status at one of the helicopter carriers (LPH's or LHA) of the seabase. If the urgent load order is from ashore, it is assigned to a helicopter, capable of performing the mission, which has completed a mission ashore. If no such helicopter is available, the urgent load order is assigned to a helicopter on alert status at the seabase.

Orders for routine loads are separated by helicopter type. The model first attempts to assign these loads to a helicopter which is already in the air and has completed its mission. If such a helicopter is not available, the load is assigned to one of the helicopters at the LHA or the LPH's.

When the HCS has assigned the load, the message is forwarded to a helicopter. Helicopters are kept at the LHA and LPH's when not in use. The model considers only CH-46 and CH-53 helicopters for logistic requirements. UH-1N helicopters are used only for dedicated MEDEVAC missions. Two CH-46 and two CH-53 helicopters are kept on a five-minute alert status at all times for the assignment of urgent missions. When a helicopter receives a load order while not on alert status a service time is assigned for movement to the flight deck. A check is made for the location of the pickup point. If the pickup point and the location of

the helicopter are the same, a service time is assigned to put the load aboard the helicopter. The helicopter then takes off and is assigned a service time for transit to its destination.

The helicopter lands at its destination when space at the helopad/helodeck is available. The model considers capacities of helodecks (e.g., two helicopters cannot be on an LKA's helodeck at the same time). If a helicopter has landed to pick up a load, a service time is assigned to place the load aboard the helicopter. The helicopter then takes off and is assigned a service time to proceed to its destination. If a helicopter lands with a load, a service time is assigned for unloading the items for that drop point. If the mission is not complete, the helicopter takes off and proceeds with its mission. If the mission is complete, the HCS may assign it another mission. If another mission is assigned, the helicopter proceeds with the new mission. If the HCS does not assign a new mission, the helicopter is ordered to return to its home ship.

The logic flow for transportation by helicopter is presented in Figure 8.

3.5.2 MARLOG Flights

The model has been designed with the capability to use Marine Corps Logistic (MARLOG) flights to reduce the number of routine missions flown with small payload utilization. Routine items weighing 200 pounds or less at each pickup location are assigned to a MARLOG flight. Transportation is not requested through the LSC and HCS.

At specified times each day (0900, 1200, 1500 hours) two CH-46s are scheduled for a MARLOG flight. Each helicopter is scheduled to stop

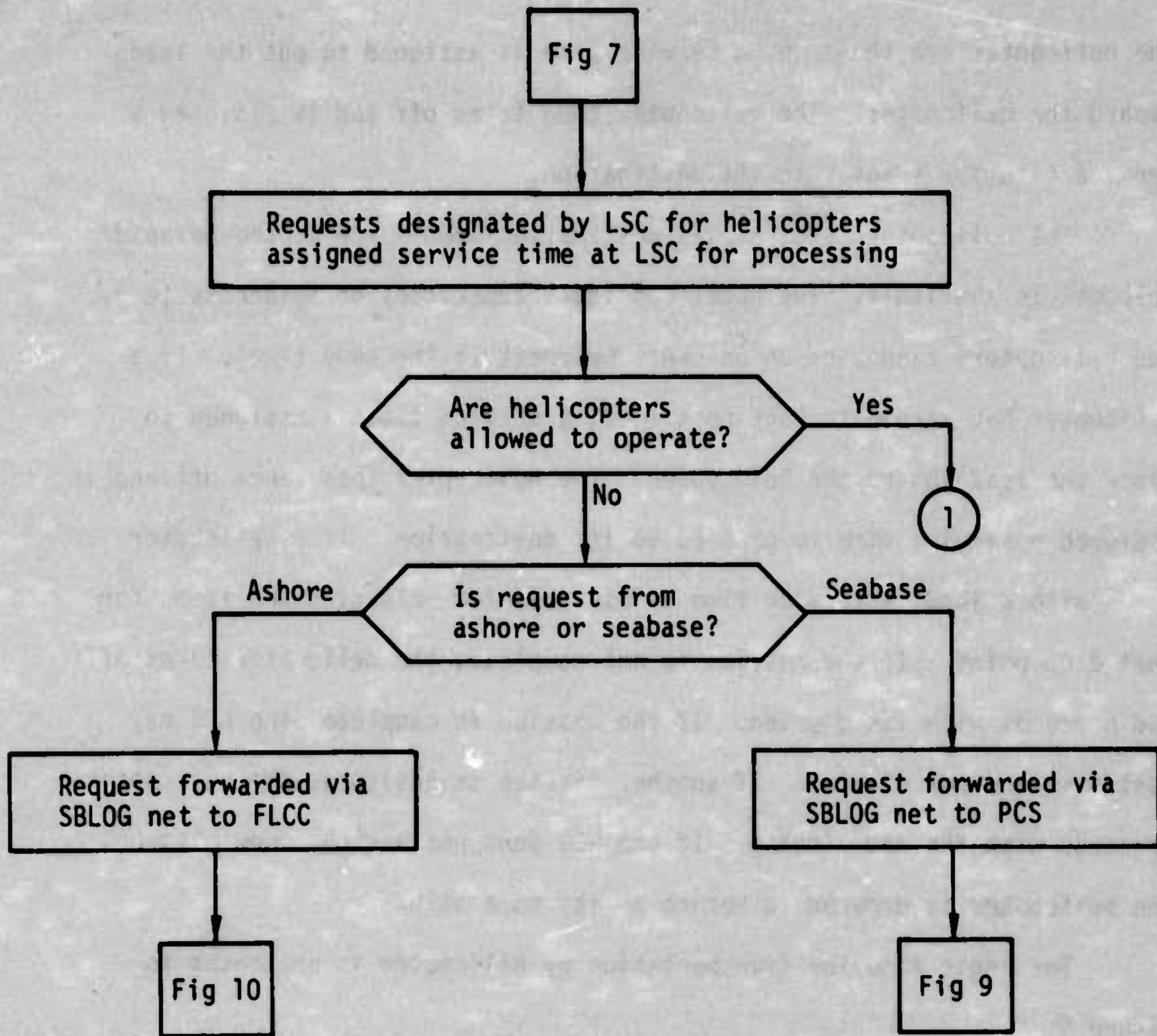
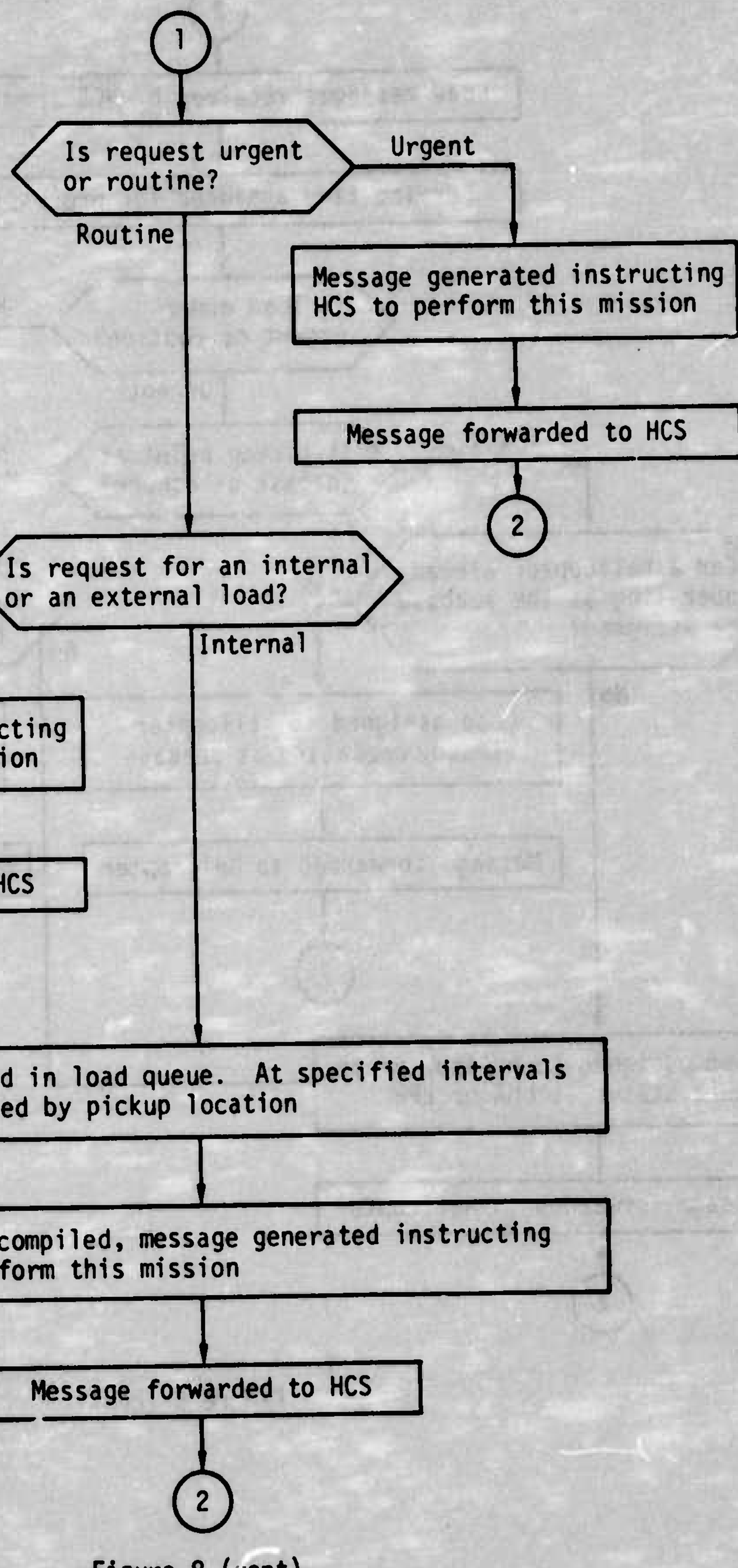


Figure 8. Helicopter Transportation Flow Diagram



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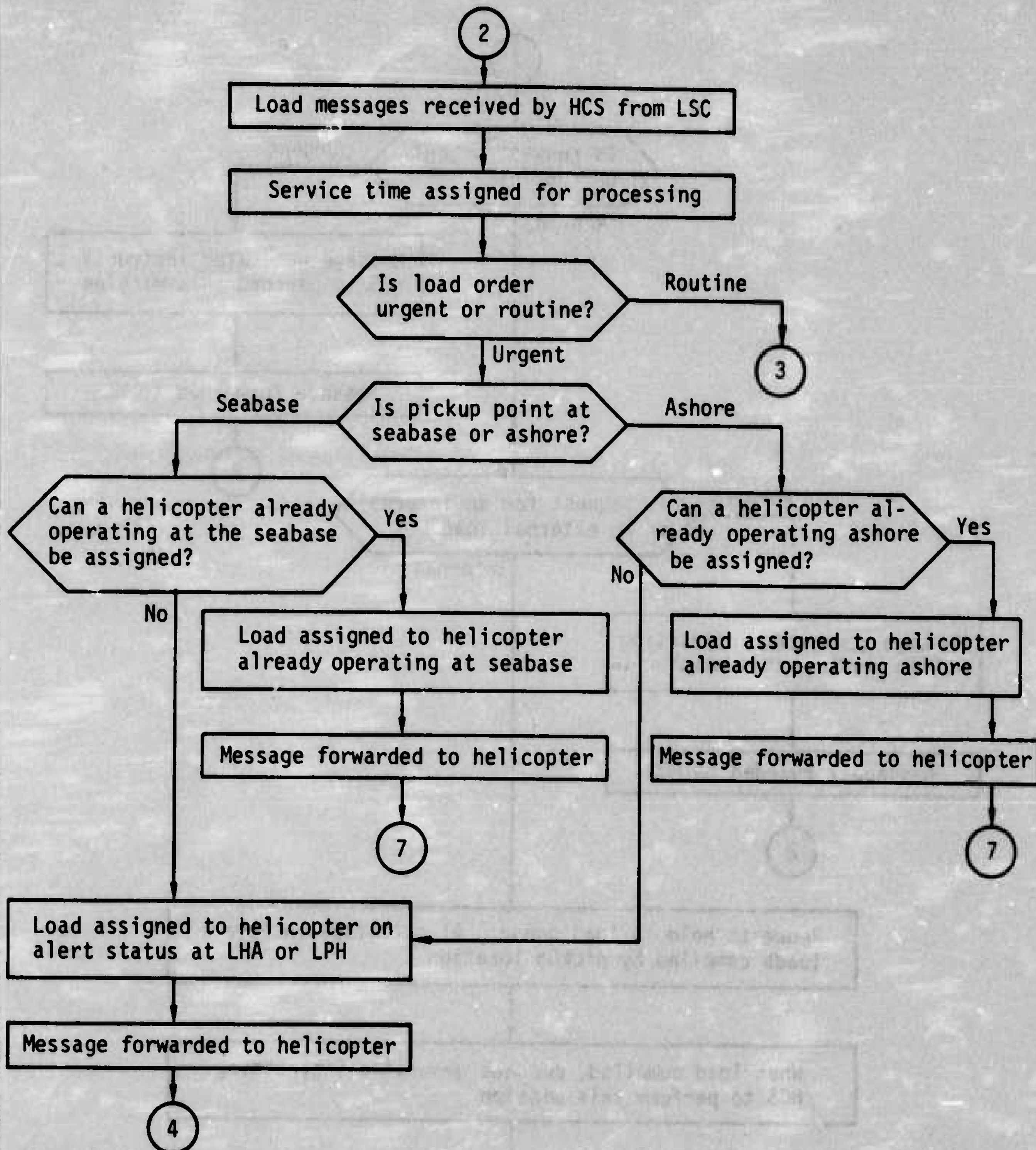

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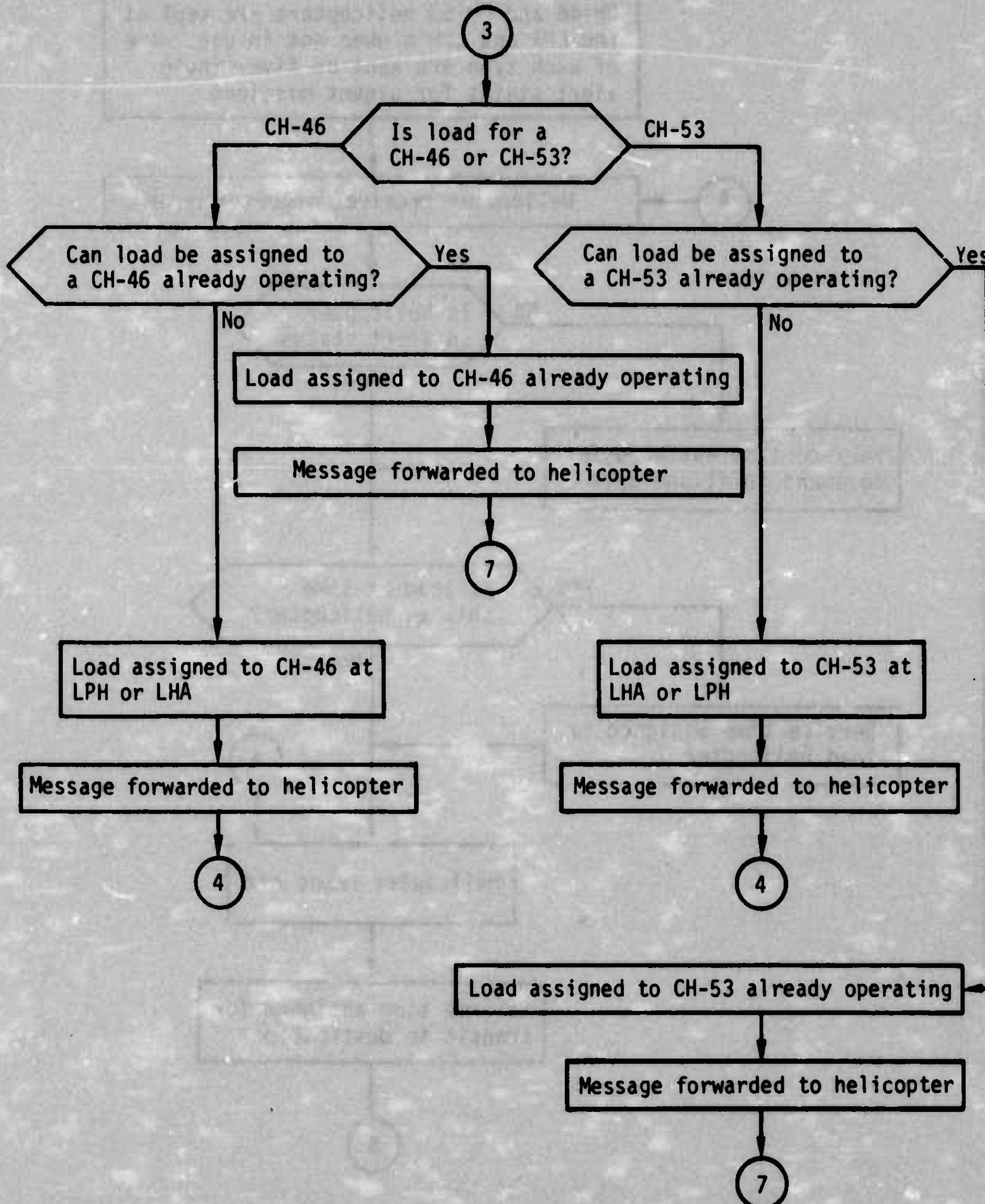

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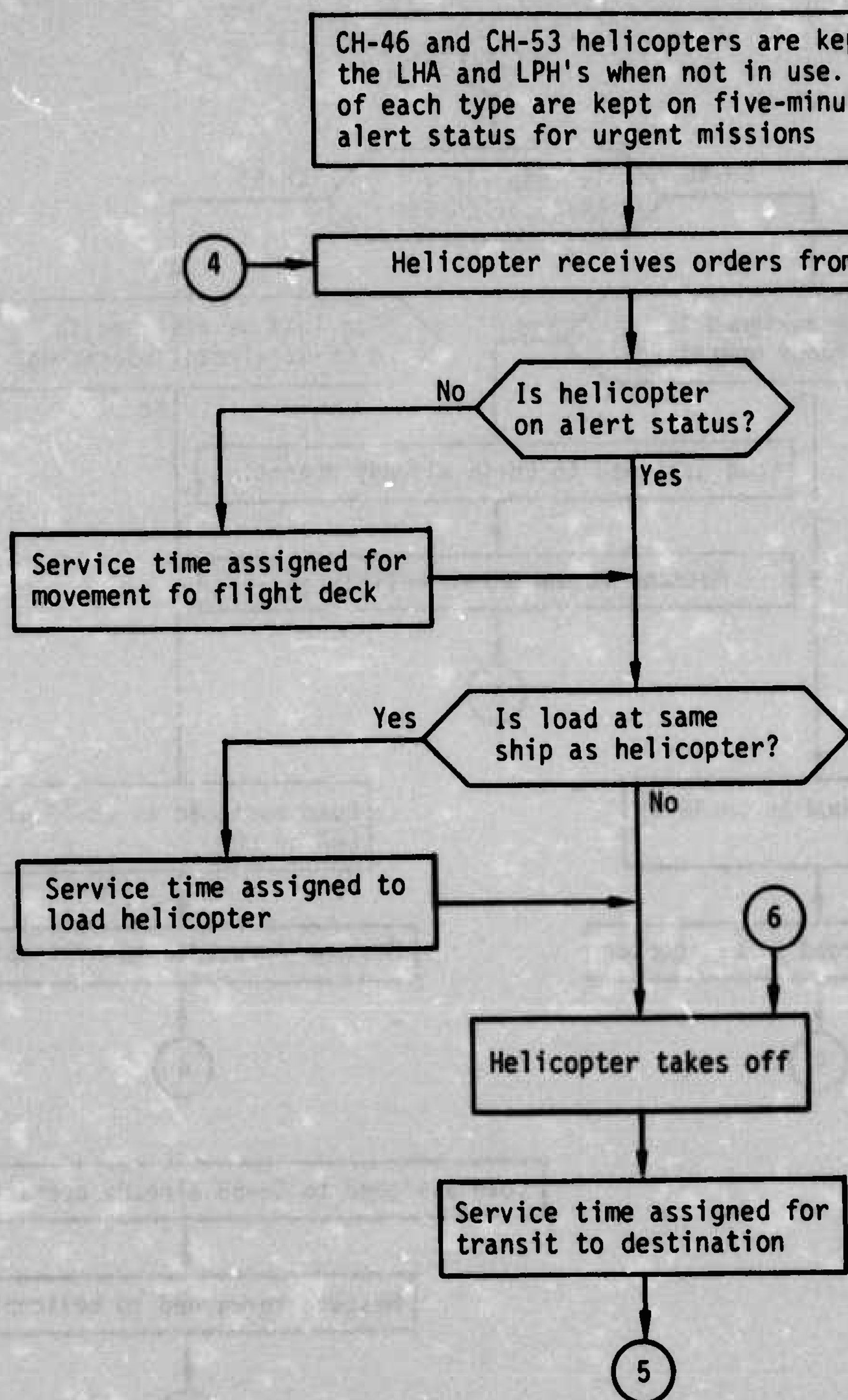

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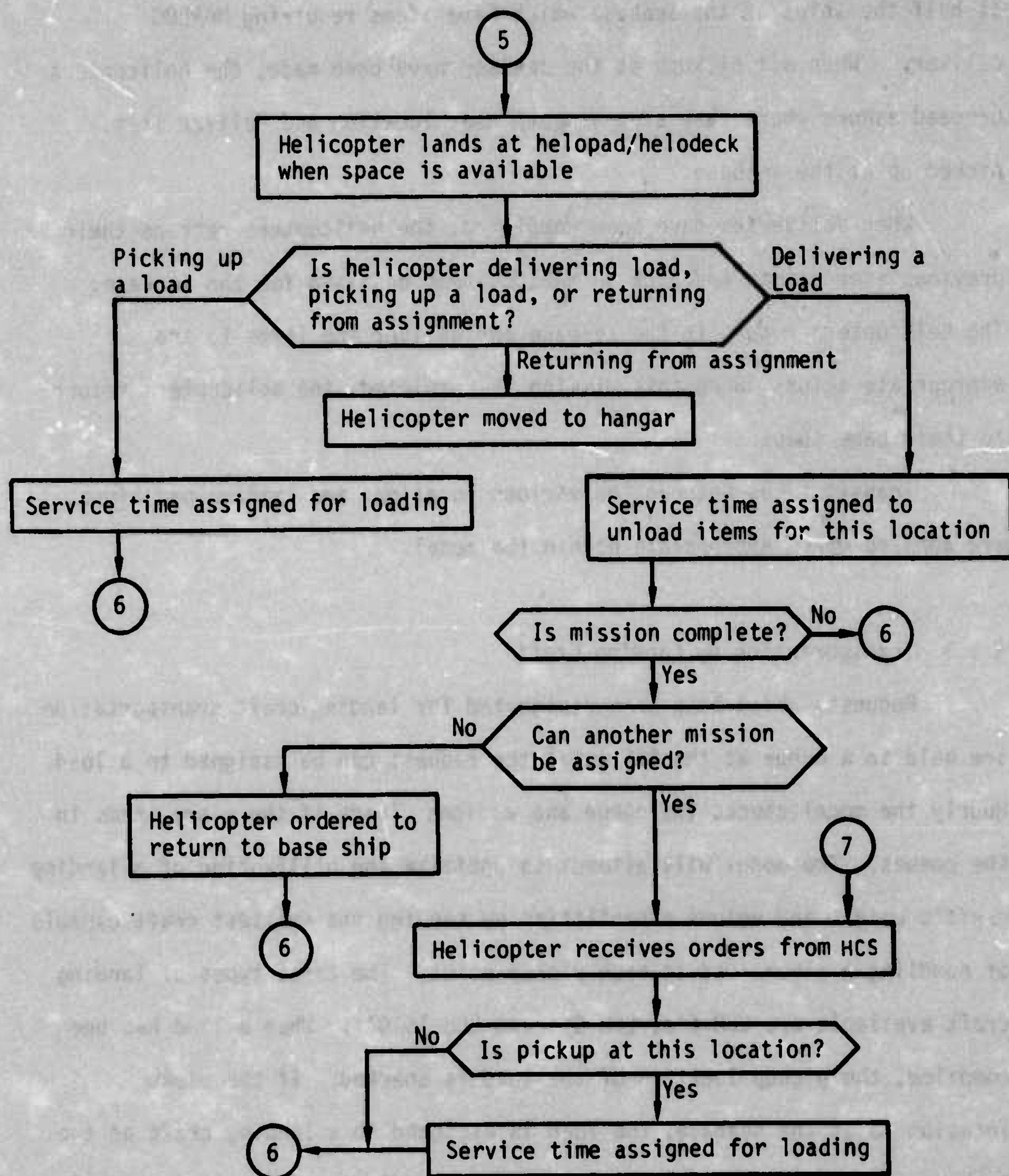


Figure 8 (cont)

at half the ships of the seabase which have items requiring MARLOG delivery. When all pickups at the seabase have been made, the helicopters proceed ashore where they stop at each user location and deliver items picked up at the seabase.

When deliveries have been completed, the helicopters retrace their previous stop points and pick up MARLOG items destined for the seabase. The helicopters return to the seabase and deliver the items to the appropriate ships. When this mission is completed, the helicopters return to their base ships.

Transit times between the various locations and load/unload times are applied where appropriate within the model.

3.5.3 Transportation by Landing Craft

Requests which have been designated for landing-craft transportation are held in a queue at the PCS until the request can be assigned to a load. Hourly the model checks the queue and assigns loads if there are items in the queues. The model will attempt to optimize the utilization of a landing craft's weight and volume capabilities by sending the smallest craft capable of handling a given load to each pickup point. The three types of landing craft available are LCM-6's, LCM-8's and LCU-1610's. When a load has been compiled, the pickup location of the load is checked. If the pickup location is at the seabase, the load is assigned to a landing craft at the seabase and a message is transmitted* to the landing craft notifying it of this fact. Service times are assigned for (1) the landing craft to travel to the pickup point, and (2) the time required to load. The landing craft then proceeds ashore in an appropriate service time. When the landing

* assumed to be transmitted via a tactical net not otherwise modeled. Service times for such transmissions are assumed to be negligible compared to landing craft transit times.

craft arrives at the beach, it is assigned a service time to unload. The model then determines whether the landing craft has been assigned a load for the return trip. If a return load has been assigned, service times are assigned for loading the landing craft, and the time required to travel from the beach to the seabase. When the landing craft arrives at the seabase, it is assigned a service time to unload. The landing craft is then stored at the seabase until another load is assigned. If, after unloading at the beach, no return load is assigned, the landing craft is ordered to return to the seabase and a service time is assigned for travel to the seabase. The landing craft is then stored until reassigned.

If the pickup location of the load is the beach, the PCS determines whether a landing craft is available at the beach or whether there is a landing craft in transit to the beach which can be assigned the load. If such a craft is available, the load will be assigned to it. The message is transmitted to the landing craft when it is at the beach. A service time is then assigned to load the vehicle and the vehicle proceeds to the seabase. An appropriate service time is applied for transit. When the landing craft arrives at the seabase, it is assigned a service time to unload. The landing craft is then stored until reassigned.

If a load at the beach cannot be assigned to a landing craft at the beach, the model assigns the load to a landing craft at the seabase. A message is transmitted to a landing craft notifying it of this fact. After a service time for transit to the beach, the landing craft is assigned service times representing the time to load and the transit time from the beach to the seabase. When the landing craft arrives at the seabase, it is assigned a service time to unload. The landing craft is then stored until the PCS assigns another mission.

Figure 9 shows the landing-craft transportation flow diagram.

3.5.4 Transportation by Truck

Requests which have been designated for truck transportation are held in a queue at the FLCC until loads are compiled. Hourly the model compiles loads based on pickup location and the weight and volume capabilities of the trucks. When the loads have been compiled, the model determines whether a truck is available at the pickup point of the load. If a truck is available at the pickup location, a message is generated assigning that truck to fulfill the request and if a truck is not available at the pickup location, a message is generated assigning a truck at the FLCC to fulfill the mission. If the truck assigned the mission is at the FLCC, the message is passed orally. Otherwise the message is forwarded via the LFLOG net to the battalion nearest the truck and then passed orally to the truck driver.

Trucks are stored at the FLCC when not in use. When a truck receives an assignment, the model determines whether the pickup point of the load is the same as the present location of the truck. If it is not, a service time is assigned for travel to the pickup point. A service time for loading the truck and a time for transit to the destination of the load are then assigned. When the truck arrives at the destination, a service time is assigned for unloading.

The model then determines whether another load is available for assignment to that truck. If another load is assigned, the procedures discussed previously are followed. If another load is not assigned, the truck is ordered to return to the FLCC and is assigned a service time

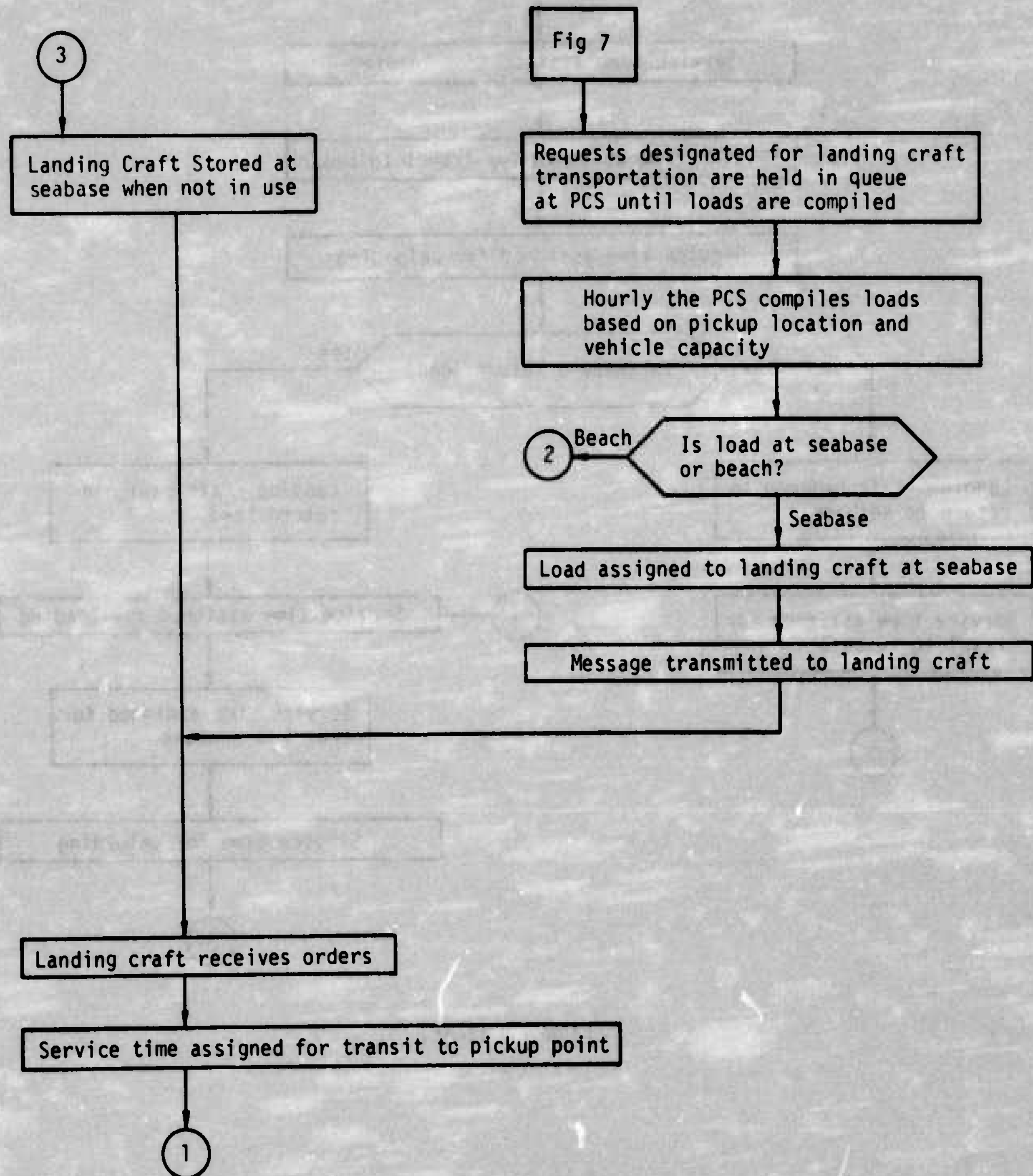
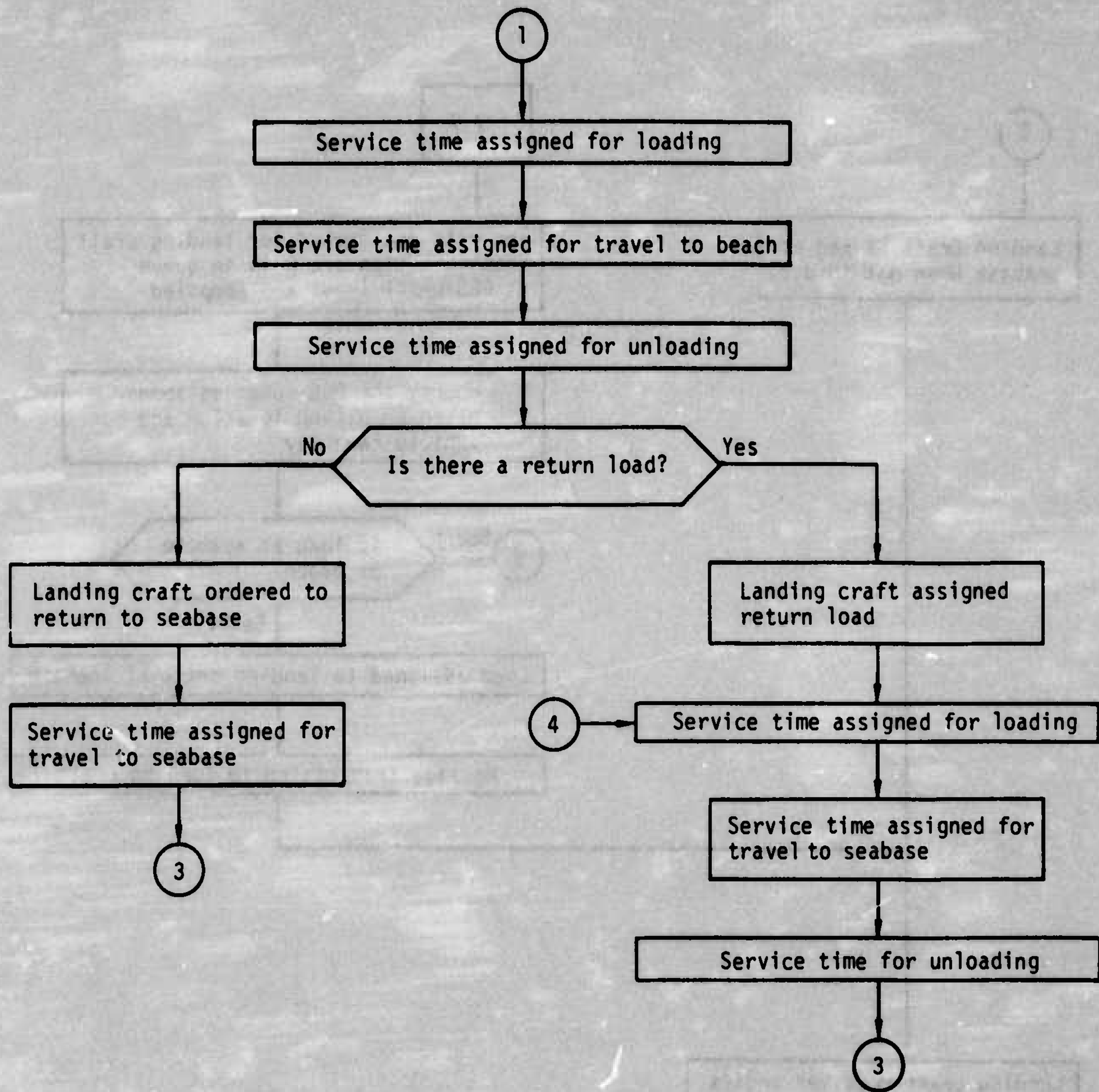


Figure 9. Landing Craft Transportation Flow Diagram



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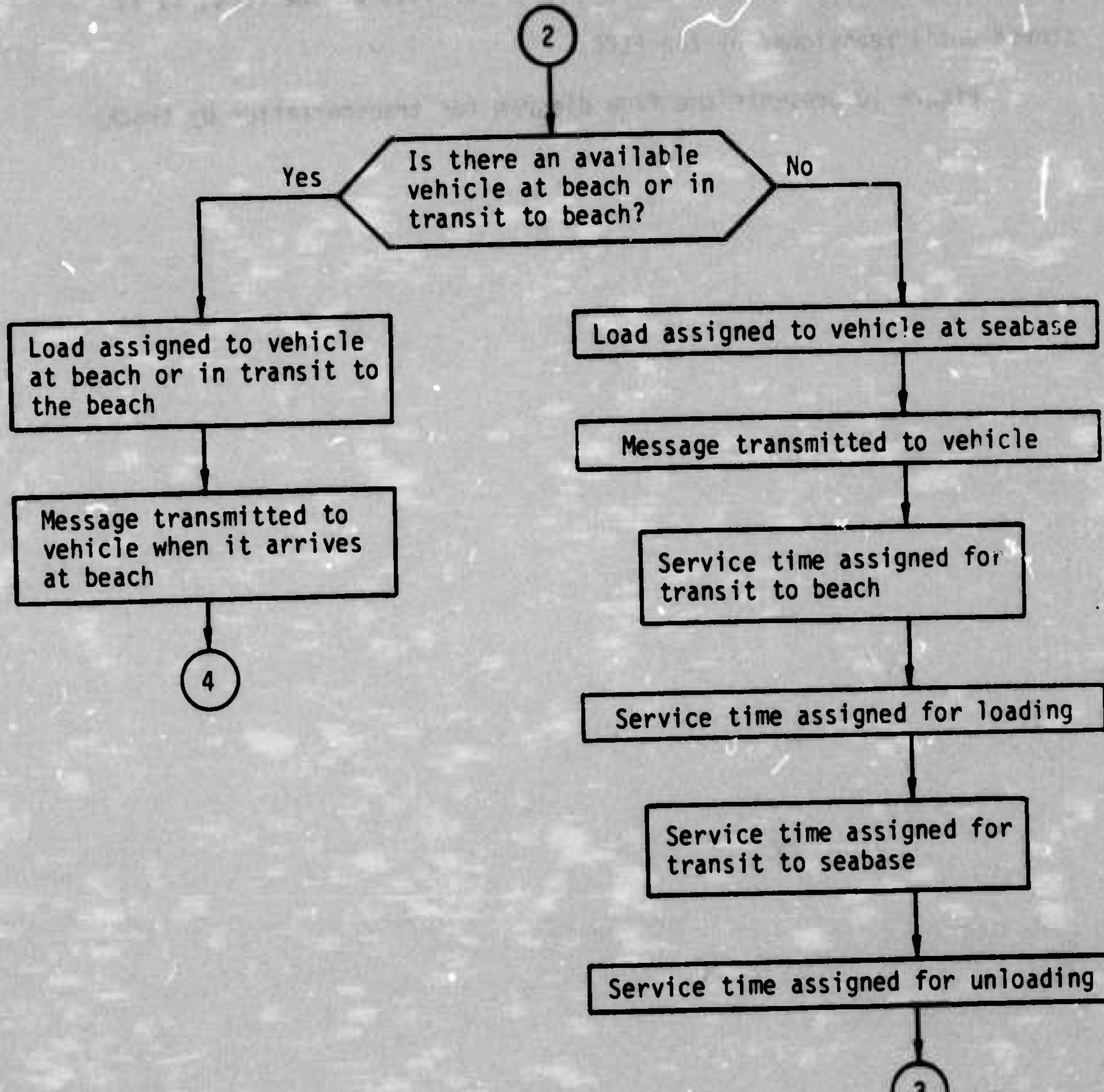

Figure 9 (cont)

representing transit time. When the truck arrives at the FLCC, it is stored until reassigned by the FLCC.

Figure 10 presents the flow diagram for transportation by trucks.

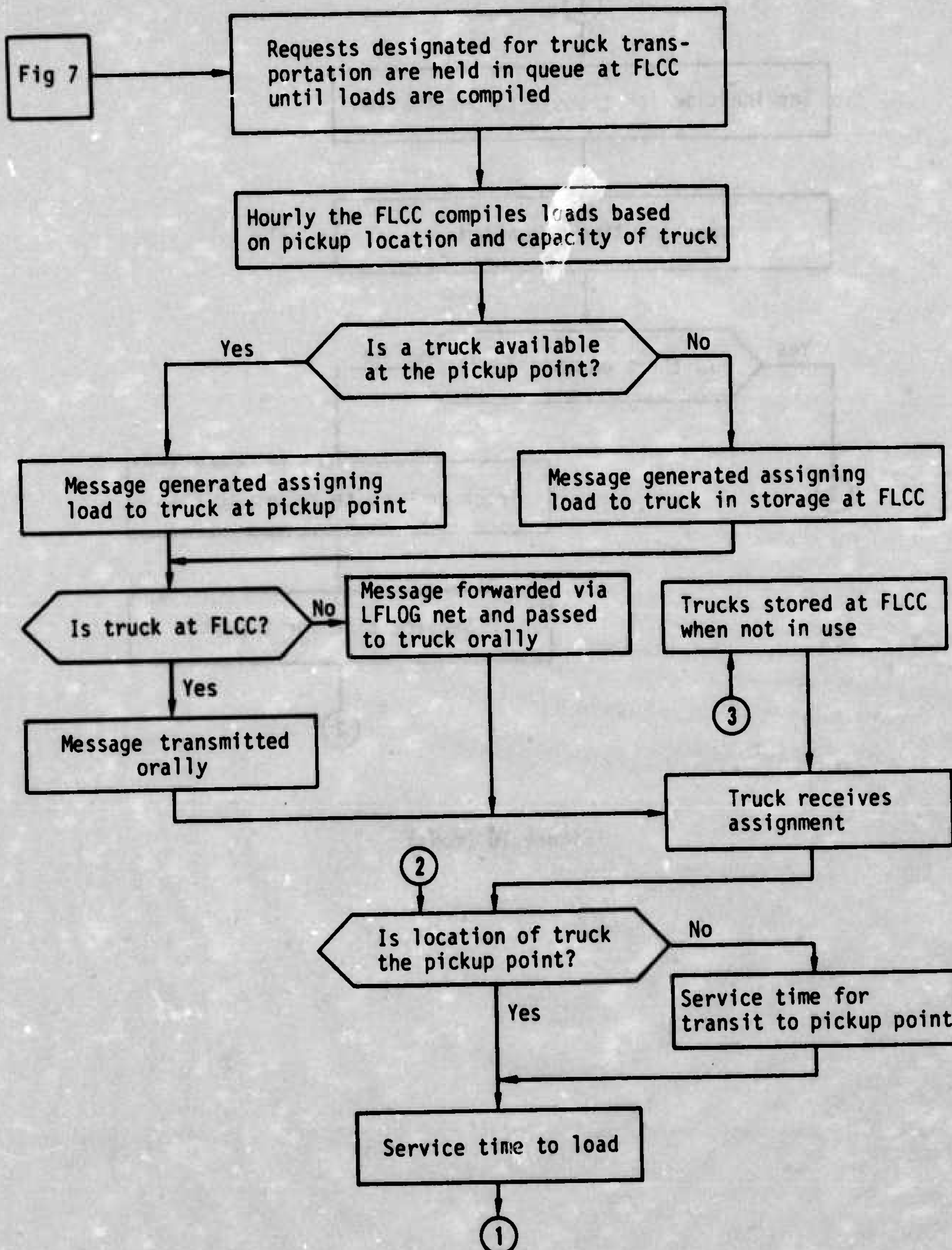

Figure 10. Truck Transportation Flow Diagram

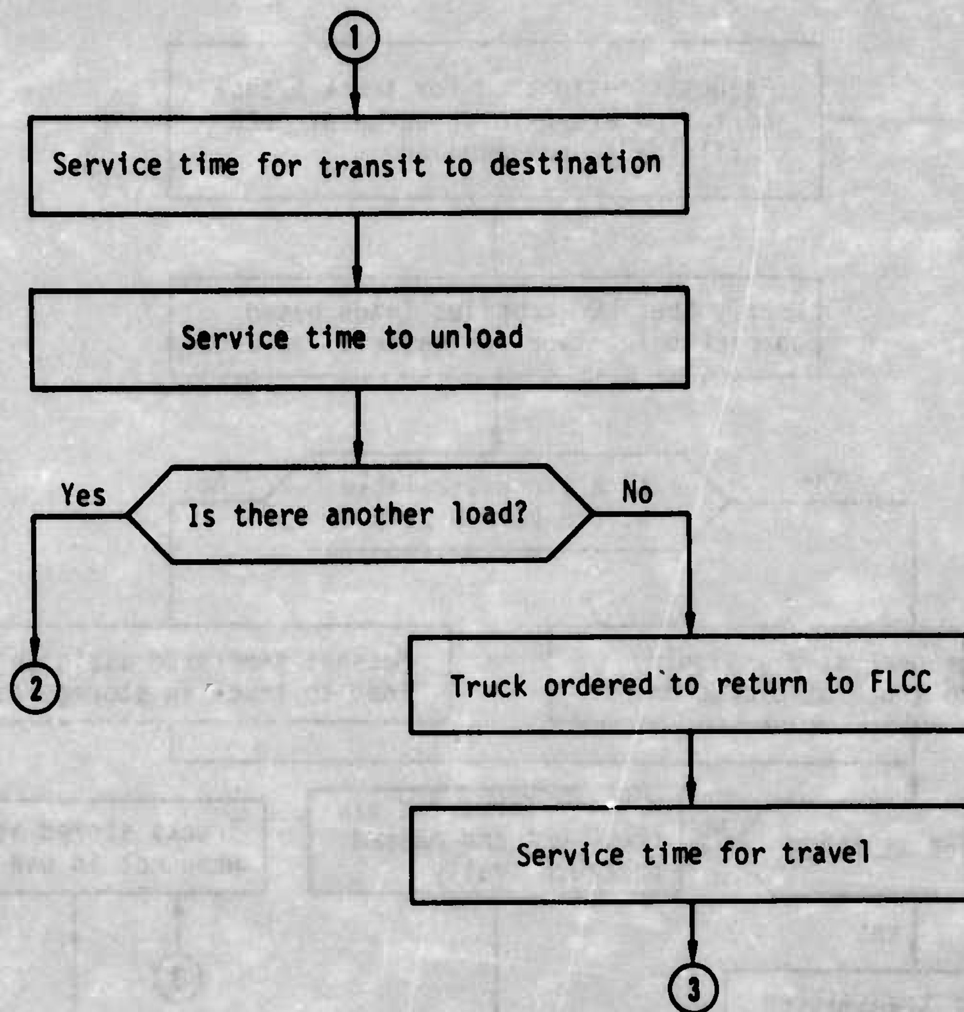

Figure 10 (cont)

4. INPUT DATA REQUIREMENTS

The input data requirements for the communications, medical, supply, maintenance, and transportation subsystems are presented in Tables 1 through 5, respectively. Quantitative values for these requirements will be published in the ATG/MAB analysis report.[5]

TABLE 1 - COMMUNICATIONS SUBSYSTEM INPUT DATA

TIMES (for each message)

- ° Pre-transmission processing service time
- ° Transmission service time
- ° Post-transmission processing service time

TABLE 2 - MEDICAL SUBSYSTEM INPUT DATA

REQUIREMENTS

- ° Number of transportation requests for MEDEVAC's per day (min., ave., max.)
- ° Distribution* of requests by time of day (percentage)
- ° Distribution* of requests by priority (percentage)
- ° Distribution* of requests by location (percentage)

RESOURCES

- ° Number of dedicated MEDEVAC UH-1N helicopters stationed at the FLCC (integer constant)
- ° Number of backup UH-1N's used for MEDEVAC missions (integer constant)

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* See Ref. 5

Table 2 (cont.)

DECISION CRITERIA

- Distribution of casualty-receiving ships to which urgent casualties are sent (percentage)
- Distribution of casualty receiving ships to which routine casualties are sent (percentage)
- Hours during which helicopters cannot be flown for urgent MEDEVAC missions
- Hours during which helicopters cannot be flown for routine MEDEVAC missions

TABLE 3 - SUPPLY SUBSYSTEM INPUT DATA

REQUIREMENTS

- Number of urgent requests per day for each supply class (min., ave., max.)
- Distribution of urgent requests by location for each supply class (percentage)
- Distribution of urgent requests by approximate weight of loads (percentage)

DECISION CRITERIA

- Time-of-day delivery restrictions for urgent resupply (i.e., interval when supplies cannot be delivered)
- Time-of-day delivery restrictions for routine resupply
- Distribution of ships on which supplies by class are located and from which they are drawn (percentage)
- Statements as to whether or not urgent supply requirements are to be drawn from safety stocks for specific cases

TABLE 4 - MAINTENANCE SUBSYSTEM INPUT DATA

RESOURCES

- Availability of repair parts; i.e., percentage of failures for which repair parts are available in Seabase by sub-commodity area
- Availability of replacement from Operational Readiness Float by sub-commodity area vs time since start of operation (percentage)
- Number of shop spaces for each sub-commodity area (integer constant)
- Distribution of maintenance shops by ships (percentage) by sub-commidity area
- Number of contact teams for each sub-commodity area (integer constant)

REQUIREMENTS

- Total number of all types of failures per day (min., ave., max.)
- Distribution of failures by sub-commodity area (percentage)
- Distribution of failures by time of day for each sub-commodity area (percentage)
- Distribution of failures by priority for each sub-commodity area
- Distribution of failures by location for each sub-commodity area (percentage)
- Distribution of failures by repair echelon (percentage)
- Percent of third-echelon jobs which are contact-team repairable for each sub-commodity area
- Percent of 2nd, 3rd, and 4th echelon jobs for which repair parts are required for each sub-commodity area

Table 4 (cont.)

- Percent of time equipment operators can diagnose problem without assistance of contact teams
- Time to receive parts from outside seabase (if not longer than time to end of mission)

DECISION CRITERIA

- Time when shop spaces are operated (time interval)*
- Time when contact teams are not scheduled for work (time interval)
- Statement as to whether or not units have second-echelon repair capability

* Twenty four hours/day has been used so far in the analysis

TABLE 5 - TRANSPORTATION SUBSYSTEM INPUT DATA

RESOURCES

- Number of CH-53 Helicopters assigned to operation (integer constant)
- Number of CH-53 Helicopters available for transportation missions (integer constant) Note: Initially provided as a percentage of the number of helicopters assigned; the factor takes into account helicopter downtime.
- Number of CH-46 Helicopters assigned to operation (integer constant)
- Number of CH-46 Helicopters available for transportation missions (integer constant)
- Number of UH-1N Helicopters assigned to operation (integer constant)

Table 5 (cont.)

- Number of UH-1N Helicopters available for MEDEVAC missions (integer constant)
- Number of LCM-8 landing craft available for transportation missions (integer constant)
- Number of LCM-6 landing craft available for transportation missions (integer constant)
- Number of LCU-1610 landing craft available for transportation missions (integer constant)
- Number of M-35 trucks available for transportation missions (integer constant)
- Number of M-54 trucks available for transportation missions (integer constant)

DECISION CRITERIA

- Time interval when helicopters are not to be dispatched for routine missions
- Time interval when helicopters are not to be dispatched for urgent missions
- Modes of transport for resupply items, ORF replacement items, repaired items, and failed items being returned to the seabase

5. SMLS SIMULATION MODEL MEASURES OF EFFECTIVENESS

To evaluate the SMLS concept, certain parameters which describe the system performance, or measures of effectiveness (MOE's), have been developed. The MOE's provide data on the time needed to fulfill requirements (response time), the availability of assets, the utilization of assets, and the length of the waiting lists or queues at various locations. Availability, as defined here, is the percentage of the time that an asset is available for assignment to a request or mission. Utilization is the time that an asset is in use. Table 6 lists the MOE's developed for use in the simulation model.

TABLE 6 - MEASURES OF EFFECTIVENESS USED IN THE SMLS SIMULATION

SUBSYSTEM	MEASURE OF EFFECTIVENESS
Medical*	° Time from occurrence of casualty to arrival of transportation ° Time from occurrence of casualty to casualty arrival at ship
Supply*	° Time from staging of supplies at seabase to arrival of transportation ° Time from submission of request to arrival of supplies at requesting unit
Maintenance*	° Maximum and average lengths of shop queue by sub-commodity class ° Maximum and average times in shop queue by sub-commodity class ° Maximum and average lengths of contact-team queue at FLCC by sub-commodity class ° Maximum and average times in contact-team queue at FLCC by sub-commodity class ° Maximum, average, and minimum maintenance response times by sub-commodity class
Transportation	° Helicopter utilization by type ° Landing craft utilization by type ° Truck utilization by type ° Helicopter utilization by class of service (maintenance, supply, MARLOG, medical)

Table 6 (cont.)

	° Landing craft utilization by class of service (maintenance, supply, medical)
	° Truck utilization by class of service (maintenance, supply, medical)
	° Number of helicopters which can be assigned missions vs time
	° Number of landing craft which can be assigned missions vs time
	° Number of trucks which can be assigned missions vs time
Communications*	° Length of message queue for each net vs time
	° Utilization of each net

*Statistics available by priority

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